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German Air Force Air Defense Operations by Generalmajor a. D. Walter Grabmann

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1542 Under the existing conditions the night fighter units had to help themselves by giving newly received replacement personnel training within the unit in the methods of night fighter operations. During the initial stages of the build up of the new arm the shortage of aircraft left little opportunity for such training activities, which from the autumn of 1943 were only possible on a limited scale in the rear areas during daylight, and from 1944 on were hardly ever possible anywhere because of enemy air supremacy over German territories.

The outcome of the above circumstances was that, although the night fighter arm had a steadily growing strength of personnel, a few experts remained those who shot down the majority of the enemy planes accounted for. One point that should have given cause for thought at an early stage was that, with a few exceptions, the "aces" of the night fighter arm were officer pilots supported by experienced radio operators. The performances of the bulk were entirely disproportionate, taken on an average, to the enormous expenditures they incurred.

The following experiences can be deduced and lessons learned from German night fighter training:

a. Each special type of force must have its own specialized training units;

a. Physical, psychological, and intellectual require-

1543 requirements must be stated as the determining factors in the selection of personnel for the night fighter arm;

c. In view of the constantly varying quality of flight personnel, a system of quality-priorities must be established and adapted to the fluctuating circumstances;

d. The severer the demands which an activity makes on personnel, the higher should be the value placed on natural aptitudes and training;

e. The only possible way to maintain lively contact between the front line forces and training activities is to insure that the front line forces shall be able to exercise a direct influence on the selection and training of replacement personnel, and to maintain a lively rotation between instructor and front line personnel.

1544 III. TWIN-ENGINE FIGHTER AIRCRAFT IN AIR DEFENSE.

The twin-engine aircraft was developed initially as a heavy fighter for large-area defense missions but in 1939 was included in the agressive air forces to provide escort protection. The role it played in daytime air defense during the war was of only short duration.

Primarily, twin-engine aircraft could be considered as predestined for air defense missions in coastal areas, where operations at sea were a part of the air defense mission and a twin-engine plane with a full complement of navigational equipment could operate with greater safety than a single-engine plane.

Whenever the German Me-110 twin-engine units encountered enemy bombers they were able to achieve excellent results owing to their exceptionally heavy fire power. Twin-engine fighters contributed to the resounding defense victory in the Bight of Helligoland on 18 December 1939, and while employed in the air defense of Norway any enemy plane they encountered could be considered lost, although such encounters were few.

It was only in the summer of 1943, after reestablishment of the 26th and 76th Twin-Engine Fighter Wings, for participation in the home air defense mission, that twin-engine daytime fighter forces again became an important factor of air defense.

1544 The twin-engine fighters in these two groups were superior to the daytime single-engine fighters in two respects:

1. The armament with four Type 17 machnie guns and two 20-mm cannon, centrally mounted in the turret, gave them heavier fire power;

2. The fact that they could operate in all weather and that they had all navigational equipmentrequired.

Another point in favor of the twin-engine aircraft was that it carried a radio operatdr. This was some moral support for the fighter and made it easier for him to be courageous, and this was the all-important requirement in an encounter with American 4-engine bombers.

Whenever they encountered enemy bomber formations operating without fighter escort, the twin-engine fighter units in every way fulfilled what had been expected of them. In spite of the great risk due to their large size they showed a high average in enemy planes shot down, although these results were often achieved at a heavy cost in own losses.

When the enemy extended their fighter escort operations into the interior of Germany in 1944 it was no longer possible for the German twin-engine fighter forces to execute their mission. Both the Me-110 and the Me-410 were too inferior in performances to the enemy fighters. They continued in service in the Home Air Defense System for some time in the

1545 hope that it would be possible through clever direction of their operations to insure that they would always encounter enemy 4-engine bomber formations operating without fighter escort. Whenever this happened they achieved excellent results, but when they unexpectedly encountered enemy fighters they incurred heavy losses.

Starting in the spring of 1944, the twin-engine units were therefore gradually reequipped with single-engine fighter planes for daytime air defense.

The success they achieved while in service proved, nevertheless, that heavy armament and all-weather operability
1546 were the important conditions for success in air defense against the American 4-engine bomber forces

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1547 IV. FIGHTER AIRCRAFT DEVELOPMENT AND PRODUCTION

1. Daytime Fighter Aircraft.

a. Striking Range. Although the 1919 Treaty of Versailles prohibited the possession of air forces by Germany, the contacts which commercial circles of the aircraft industry had abroad made it possible to continue the development of military types of aircraft on the basis of experience gained in World War I. Thus, the firm of Junkers constructed its K-47 as a two-seater fighter and reconnaissance plane; Heinkel its He-50 as the prototype of the He-51 which followed later; and Messerschmitt even prior to 1933 was working on revolutionizing ideas in the designing of aircraft, which resulted already in 1934 in the first model of the Bf-109, which showed completely convincing performances in its flight trials.

When the matter of the build up of a German fighter force became a current problem in 1933 it became necessary to decide whether to follow the conventional ideas of Heinkel and the similar ideas of Arado incorporated in the Ar-64 and Ar-65 or to adopt the revolutionizing course shown by Messersmitt with the Bf-109.

From experience with former designs by Messerschmitt it was known that in the matter of stability he ventured to the extreme minimum limits in order to translate engine power

1547 plus smallest possible weight into maximum technical performances. Furthermore, experience in World War I had developed certain concepts of what a fighter plane should be, and major points in these concepts werethe requirements of unobstructed vision, ability to land and take off without complications at field air strips, and high maneuverability for curving contests in air battle. A low-wing cabin type model as a high speed fighter plane was contary to all traditional views in this field, and no experience was available on the possibilities of a plane of this type. For these reasons the question of which types of fighter aircraft should be constructed was decided in favor of the conventional types, the Ar-64 and He-51, models which were available for immediate production and which involved no unknown risks.

This gives rise to the question of whether it would not have been wiser to decide already in 1933 in favor of the Bf-109. This question must be answered in the negative:

(1) In 1933 the Bf-109 was still in the development stages; the problematical factor in the development was the engine rather than the fuselage.

(2) Heinkel and Arado from the outset adapted their designs to the BMW VI aircraft engine, available from German manufacture, so that their models could immediately be placed in serial production.

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1548 (3) The all-important point for the Luftwaffe was to activate a number of units as speedily as possible. For this reason the decision had to be in favor of what could be made available immediately.

(4) Although adoption of the conventional models meant that the German units initially would be equipped with aircraft which were not superior to those of adjacent foreign powers, the time gained through this decision represented important advantages in general in the military and political fields.

(5) The possibility existed for a systematic transition to the new model as soon as enough experience was available on the Bf-109 and after the theoretical concepts of the modern missions of a fighter arm had been clarified.

The principles expounded in Air Field Manual LDv 16 on the missions of a fighter arm visualized such an arm primarily as a weapon of defense closely restricted within a specified area. This view played a fundamentally important role in determining the nature of a fighter plane so far as its striking range was concerned.

For operations within a restricted area a time-in-air capability of 1-1½ hours was considered adequate. Therefore, the governing factors for the aircraft designer were the engine and its fuel consumption, which had to be such that

1549 the plane could carry a fuel load sufficient for the stated duration of flight. Given these factors, the aim was to arrive at the most favorable ratio between engine thrust and the overall weight of the aircraft under development.

This explains why not only the original He-51 and Ar-65, as well as the Ar-68, powered by a Jumo-210 engine, but even the Bf-109 of the A-C series were designed and constructed for an overall time-in-air capability of 1¼ hours.

While the above points were under consideration work was already in progress to develop stronger engines designed to take the place of the Jumo-210 type. Thus, Daimler-Benz was developing the DB-601, and Junkers was developing the Jumo-211, both of which had a far bigger fuel consumption.

The installation of reserve fuel tanks in the wings in 1938 gave the Bf-109 of the D series an increased overall time-in-air- capability of two hours.and thirty minutes. This was done to meet the requirement stated by the Commander in Chief of the Luftwaffe in September 1938 "to develop a fighter with a striking range adequate to cover England."

However, the results obtained with the reserve fuel tanks by no means met the stated requirements. To "cover England" would have required a penetration range of 510 miles from the most westerly situated airfields in Germany. Allowing a

1550 reserve for combat action, this implied a required tactical penetration range of 600 miles, and at best the Bf-109-D had only one-half of the capability.

From the above it seems obvious that no doubt could have existed in 1938 that, in the event of operational air warfare against Britain, the Bf-109-D could not be counted on to provide escort protection for the attacking German bomber forces.

With the changeover of the Bf-109 in 1939 from Jumo-210 to DB-601 engines, the higher fuel consumption rate of the newly introduced power plant reduced the time-in-air capability of 2½ hours in the case of the Bf-109-D to only 1¼ hours in the case of the Me-109-E. No possibilities existed to instal more reserve fuel tanks in the plane.

It can thus be seen that the cause for the inadequate striking range specified in the development of fighter aircraft types was inherent from the outset in the tactical specifications stated by the Luftwaffe on the basis of the existing concepts of direct target defense principles.

1551 Throughout the war, even after theoretical concepts had developed to a stage where the fighter mission comprised entirely new tasks requiring a considerably increased tactical radius of action, the German fighter arm continued to suffer from the results of its faulty start.

The solution adopted later of mounting a 300 liter

1551 (roughly 79 gallon) reserve fuel tank under the fuselage was a poor improvisation, since it reduced the plane's speed by 24 miles, increased the time required for climbing, and impaired the general flight properties of the plane.

On the British side the original specifications for fighter planes already had required a time-in-air capability of 2½ hours. This gave the British fighters a larger radius of action from the outset, although the area they were to defend was considerably smaller than Germany.

The pernicious effect of this basic flaw in the whole German concept was continuous. The FW-190, newly developed at the outbreak of war, had a capability of barely 1¼ hours. It is hard to understand why specifications did not require longer flight duration in this new plane, since it was already known in the case of the Me-109-E what a serious handicap that plane's short time-in-air capability represented in the execution of operational missions.

The same flaw was inherent in the Me-262. Its tactical time-in-air capability of fifty minutes at an altitude of at least 1650 feet gave it a penetration range of 150 miles, which was no more than that of the Me-109 and FW-190 without their reserve fuel tanks.

The He-162 "Volks" fighter ha approximately the same flight duration as the Me-262 but was slower, and therefore

1551 had a smaller penetration range.

1552 In comparison with the above figures, the first American jet fighters placed in operation, the F-80 and F-84, had a basic time-in-air capability of $3\frac{1}{2}$ hours, which shows that they were developed for a greater radius of action.

From all of the above it is obvious that the German fighter models did not meet the tactical requirements for large area operations. It can be assumed with certainty that German aircraft designers would have been just as able as their American counterparts proved to be in the case of the P-51 and F-84 to design and develop a high capacity fighter plane with a greater striking range if the Luftwaffe had specified such requirements in good time.

If it is of interest to establish who was responsible for the above failure on the German side, this can be established from the following:

(1) The requirements stated by the Chief of Special Supplies and Procurement on 20 October 1942 for the development of a new fighter model specified as follows:

"Speed to increase up to the speed of sound;"

"Number and effectiveness of weapons to be increased."

"Improved flight performances coupled with the best possible properties for take off and landing."

"Development and production of efficient jet

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1552 engines making possible a progressive increase in time-in-air capacities."

(2) In a conference between General Koller, Chief of the Luftwaffe Operations Staff, and Field Marshal Milch on 21 March 1944 General Koller called for a "heavy fighter capable of 4 hours of sustained flight." Field Marshal Milch's reply to this demand was "We need numbers, and these we can only have in the light types." With "light types" Field Marshal Milch meant the Me-109 and the FW-190.

Since experience shows that the development of a new type of fuselage takes three, and that of a new type of engine five years, the requirements stated in 1942 should have been stated in 1939, at the outbreak of war, in order to have the specified type of fighter plane available in 1944, a plane which would combine the qualities of high technical performances and long time-in-air capabilities. Any specifications stated in 1944 for a new weapon to meet a current situation were illusory from the outset.

b. Flight Performances of German Daytime Fighters. In the phase of pre-war developments , when the bomber forces of the military powers adjacent to Germany still had their old types of aircraft with a speed of approximately 90 miles, 1553 fighter aircraft such as the German He-51 and Ar-65 models with their maximum speed of 180 miles could still be considered as completely adequate for the missions of air defense against enemy bombers. Given approximately qualitative equality with foreign fighter types, all that was required for success in any contest with enemy fighter forces was the availability of appropriate numbers.

Prior to the introduction of the Bf-109 in 1938 the Luftwaffe would hardly have been able to hold its own in any military conflict involving fighter forces since, if opposed to the old Entente Cordiale powers, the enemy from the outset would have had numerical superiority. Up to 1938 the German fighter arm thus had no realistic combat value because it lacked adequate numerical strength and superior aircraft.

This situation underwent a fundamental change with the introduction of the Bf-109. The enormous improvement in performances which an increase of more than 90 miles in maximum speed represented created a qualitative superiority adequate to compensate for any degree of inferiority in numbers.

How great the new advantage really was first became evident when the Bf-109 was engaged in actual combat in Spain in 1937. Events there proved that even as many as 50 or 100 Rata or Curtiss planes stood no chance whatever against only 2 Bf-109 planes, but that these two planes had every chance

1554 to master the air whenever and wherever they wished.

It was this factor of superior aircraft performances which in 1939-40 enabled the German fighter forces to establish air supremacy over Poland and in France, although faced by a numerical superiority. This aircraft superiority was also a determining factor in the Balkan campaign and in the initial stages of the campaign against Russia.

In spite of all this, however, there was a moment during the 1940 Air Battle for Britain which should have produced certain reactions in the German Air Command. This was the moment when an improved model of the British Spitfire made its first appearance as a plane which was superior in climbing ability, curving performances, and high-altitude operations to the Me-109 anthough not as fast.

This made the matter of improving the aircraft performances of the German fighter arm a problem of current importance if a factor was still desired to compensate for German numerical inferiority.

On the German side it was hoped that a changeover to engines with improved performances would produce adequate results. The new DB-601-N engine with its Glykol cooling system, an operating temperature of 248° Fahrenheit, and a drive which gave the plane a maximum speed increased by 24 miles, insured that the Me-109-E/N would be slightly superior

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1555 to the British Spitfire. Me-109 planes of the new, F, Series were to have better curving ability and improved stability at high altitudes and thus remove the superiority of the Spitfire in these respects.

The DB-605 engine introduced in 1943 for installation in the unchanged fuselage gave the German fighter a thrust of 1700 horse-powere, at a time when the 2000 horse power engine was already common in Anglo-American planes.

Good results were expected from installation of the BMW-801 engine in the FW-190 fuselage. In spite of its 1800 horse power, however, this model proved no better than the Me-109-G with its DB-605 engine. In fact, the new engine gave even poorer results at high altitudes, because the full speed fuel pressure was too low, so that the performances of the FW-190 declined rapidly at altitudes above 30 000 feet.

Then followed experiments designed to increase the engine power temporarily, for short bursts of speed, through the injection of a mixture of methanol and water and of a special mixture known as GM-1.

1556 In the case of the Me-109 the installation of the DB-605 engine brought the load which the fuselage and the undercarriage could carry up to the maximum limit. A stronger engine would have called for a completely new type of fuselage.

It can therefore be stated here that the methods started

1556 in 1940 to improve the performances of the German fighter planes through the installation of more powerful engines ended in a fiasco. With their radial engines plus exhaust driven turbines and with their Rolls Royce Merlin engines, the Anglo-Americans had won a clear lead in this field. This was proof that there was a fundamental flaw in the whole German concept, a flaw which could have been avoided through a sober appraisal of certain experience factors.

These experience factors were as follows:

The superiority of the Bf-109 derived from the completely new form of its fuselage as a low-wing cabin-type plane of the smallest possible dimensions and the smallest possible weight. Its introduction gave Germany a lead over foreign powers. With the introduction of their Spitfire the enemy had almost caught up with this lead. The German belief that a bigger lead could again be established by means of increased engine power was an error which definitely could have been avoided if due consideration had been given to the known superior experience of the British and American engine construction industries.

A sober appraisal of the situation as it existed in the autumn of 1940 should have produced the realization that it was no longer possible to develop anything fundamentally new and really superior with the existing types

1556 of fuselage and with piston-driven engines. Only the introduction of an entirely new principle could result in a restored and decisive lead.

The mounting German losses in fighter aircraft in the 1940 Air Battle for Britain were reason enough to devote serious thought to these matters, but the Luftwaffe failed to draw the only possible logical conclusions. This although the only possible solution was within easy reach.

Before the war already Heinkel had constructed a plane driven by jet power alone, the He-178 with its He-S-3 radial engine giving a thrust of 1100 pounds. After tests with the He-112 single-seater fighter fighter plane, Heinkel at the same time had also developed the He-176, a plane driven by a Walter type rocket power plant. The He-176 was ready for production before the He-178 and on 3 July 1939 was demonstrated before prominent German authorities at Rechlin. It achieved a speed of 510 miles in the demonstration tests, but was rejected as uninteresting and a toy by General Udet, at that time Chief of the Technical Office.

On 27 August 1939 the He-178 showed excellent results in its first test flights and on 1 November of the same year it performed demonstration flights before a Luftwaffe commission consisting of Milch, Udet, and General (Technological Services) Lucht. Milch showed no signs of being impressed or interested.

1557 These were the possibilities which actually existed, possibilities which the Luftwaffe High Command, and particularly Field Marshal Milch and General Udet as the men responsible for air armament, should have remembered in the autumn of
1558 1940, when the problem became acute of creating something just as fundamentally new as the Bf-109 had been in its day.

The outcome of this lack of interest and lack of understanding on the part of the Luftwaffe High Command was that further development of the jet and rocket driven fighter plane was left to the private initiative of German industrialists.

Heinkel at the time was working at his He-280, an improved version of the He-178; Messerschmitt was developing his Me-262; and Lippisch, employed by the firm of Messerschmitt as a designer, was developing the Me-163.

In a discussion Professor Messerschmitt in July 1949 informed the present writer that he recommended introduction of the Me-262 already in 1940 to replace the Me-109, but that the Commander in Chief of the Luftwaffe and the Technical Office had contended that the Me-262 was much too fast for use as a fighter so that the whole project was nonsense.

On 5 April 1941 Heinkel arranged a demonstration of his He-280, driven by two He-S-8 jet power units, before General Udet, Chief of Special Supplies and Procurement, and leading

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1558 engineer personnel from the Technological Office of the Luftwaffe. In comparative tests with the newly introduced FW-190 the He-280 clearly demonstrated its superiority and completely convinced Udet. As a first result, Heinkel obtained approval to purchase the Hirth Engine Factory, Zuffenhausen, in which to produce his He-S-8 jet engines.

However, Field Marshal Milch obviously refused to be convinced of the possibilities inherent in the new development,
1559 his attitude no doubt being influenced in no small degree by his personal dislike of Professor Heinkel. He balked at the risks which the construction of new types of aircraft would involve and at all times favored the production of large numbers, which could only be achieved with types already in production.

In 1941 Milch also inspected the Messerschmitt factory at Augsburg and was able to convince himself that test flights showed that no difficulties existed so far as the Me-262 fuselage was concerned. The BMW jet engine, still under development, still presented some problems.

Messerschmitt's suggestion to step up work at development of the Me-262 was again rejected by Field Marshal Milch, however, on the basis that any such development could no longer serve any useful purpose.

Apparently Milch at the time was confident that the

1559 campaign in Russia and consequently the war as such would come to an early end.

On 15 September 1942 Milch placed development of the He-280 jet fighter in the lowest priority category.

In July 1942 the Me-262 for the first time flew with only two Junkers Jumo-004 jet engines, unsupported by the Jumo-210 piston-driven engine. In spite of this fact the Commander in Chief of the Luftwaffe in 1942 again, and this time in severe terms, ordered Professor Messerschmitt not to broach the subject of the Me-262 again.

Even if it be admitted that the prospects of the Jet fighter development did not appear too promising by the results hitherto obtained in 1940, the time was ripe in the summer of 1941 at the latest to step up development of the He-280 and Me-262 with all means available.

The worst of all was that even in 1942 Heinkel and Messerschmitt were forced to the conviction that they would have to rely completely on their own resources in the jet fighter project and that over and above this they would receive no support whatever from the Luftwaffe and in fact had to count on direct obstruction.

It can therefore be stated as an established fact that realizable possibilities existed as far back as in 1940 for the development of a completely new type of fighter aircraft, 1560 Propelled by jet or rocket power units, the new type of aircraft opened up entirely new vistas of aircraft performances. The fact is also established that advantage was not taken of these possibilities because of a lack of understanding, a faulty estimate of the situation, and personal likes and dislikes in Luftwaffe Command circles.

Following an enthusiastic report by General Galland, Chief of Fighter Forces, on a test flight he had made with the Me-262, Field Marshal Milch in July 1943 suddenly decided to give vigorous support to the construction of the new fighter, but by then almost three years had been wasted. It can be assumed with certainty that serious support of the project at an earlier stage would have saved much time.[796]

The Me-163 rocket propelled fighter development project encountered less difficulties by the Luftwaffe. This can be considered to have been due to the following causes:

(1) Being very small, this plane did not require exceptionally large expenditures in personnel or materiel for the fuselage or the power unit;

(2) Obvious points in the favor of this fighter were its speed of approximately 600 miles and the absence of any complications in the matter of landing, which it did on skids;

796. Sources 492; Heinkel, pp. 498-525.

1561 (3) The Me-163 appeared to be the ideal solution of the problem of a defense fighter to cope with enemy air reconnaissance activities using high-performance aircraft of the Spitfire IX and Mosquito types.

Owing to its short time-in-air capability of between five and eight minutes at top speeds, the Me-163 under no circumstances could be considered suitable for a general improvement in the performances of the fighter arm. The experience made wi with the few units of this type employed later in action confirmed the opinion held by certain circles that the results it would achieve were entirely out of proportion to the time and effort expended on the project.

A noteworthy attempt to bring about a considerable improvement of the performances of fighter aircraft powered by piston-driven engines was that of Professor Dornier with the Do-335. Instead of mounting the two engines of this plane in the wings, Professor Dornier's idea was to mount them in line within the body of the plane to drive a forward suction propellor and a pressure propellor installed behind the tail assembly. This did away with a considerable percentage of the retarding air friction of the normal arrangement. The soundness of the theory was proved by the fact that in its first trial the plane achieved a speed of 420 miles and gave evidence of superb flight properties.

1562 Here again it was Field Marshal Milch's reluctance to try anything new and unusual which prevented an early production of this type. Much valuable time was lost because the designer and manufacturer was left to do all the work of development on his own initiative concurrently with the requirement to fulfill his other programs.

When the Luftwaffe in 1943 finally extended its official support to the new projects and in some cases translated that support into official pressure brought to bear on aircraft factories, it displayed a complete lack of any realistic conception of what could be done in the time available, under the pressure of enemy air attack, and under the conditions of a general shortage in manpower and materials. Two years earlier many of the difficulties now encountered would have presented hardly any problem at all.

From the viewpoint of aircraft performance it can be state that at the end of the war the German fighter arm with its Me-262, He-162, and Do-335 was one stage ahead of any aircraft type the opponents could put in the air. However, all of these types made their appearance under the tragic seal "Too Late." The new types reached the front line units in too small numbers at a time when those units with their obsolete aircraft types were engaged in hopeless battle against numerically superior enemy forces which were rapidly wearing them down.

1562 All of this was the terrible outcome of the numerous errors of omission committed by the Luftwaffe High Command, which had rested too long on its laurels of "the best fighter plane on earth."

1563 c. Equipment of Daytime Fighter Aircraft.

(1) Radio and Radar. By virtue of the nature of their missions, the first German front line fighter aircraft placed in action, the He-51 and Ar-65, required only radio equipment to insure air-ground-air communications for the transmission of tactical orders and reports and of information on the position of enemy forces, and permitting intra-unit voice communications while airborne.

The question of navigational facilities was no problem since the tactics of direct target defense, the limited striking range of the fighters, and the dependence of attacking air unitsin those days on favorable weather conditions insured that fighter units would usually operate in the near vicinity of their home bases, where they would be able to memorize the salient terrain features of their area of operations after a few orientation flights.

Consonant with the stage of development reached in the field of radio technology at the time, the radio equipment of fighter aircraft consisted of a 3000-6000 KHz, 70 Watt, shortwave radio telephone transceiver. The operating range of

1563 these instruments was commensurate with the radius of action of the aircraft. Communication was usually difficult, however, owing to the loud atmospherics customary in all short-wave instruments.

Theoretically a pilot could establish his current position by means of cross orientation, taking the bearings from two ground stations. To make this possible in actual practice, however, the fighter arm would have needed a flight control organization of its own, since the radio instruments of the fighter units operated on a fixed frequency which the pilot was unable to change while airborne. The ground stations of the Air Traffic Control Service, on the other hand, operated on their permanently allocated frequencies, and to obtain a bearing from them required tuning to their frequencies.

Owing to the limited areas within which fighters would operate it was not considered necessary to establish a separate control organization for the fighter arm. Efforts in the development of fighter radio instruments were directed towards improved reception, and in this respect satisfactory results were achieved in stages through the Fu-G-3a, the Fu-G-5a, Fu-G-6a, and finally the Fu-G-7a instrument.

Introduction of the Bf-109 fighter plane considerably increased the radius of action of fighter units. In spite of this fact, however, it was considered unnecessary from the

1564 outset to provide radio navigational instruments for this fighter type. The question presents itself to the mind here, whether this decision was still sound at the time, in 1938.

The reply must be in the negative for the following reasons:

(1) In 1938 theoretical concepts on the subject of the missions of a fighter arm were already largely oriented towards the operational use of fighters as escorts for the protection of bomber forces; In the execution of such missions it was thus necessary for the fighters, when operating far inside enemy territory, to have radio navigation instruments similar to those of the bomber units;

(2) If fighters operating over long distances remained dependent upon good weather conditions making ground orientation possible, the possibility to commit bomber forces in operations would be contingent on weather conditions suitable for fighter operations;

(3) The order issued by the Commander in Chief of the Luftwaffe in September 1938 to develop a fighter with a range adequate to cover the whole of England, included the necessity of radio navigation instruments for such a fighter.

1565 It would have been possible in those days to instal in fighter aircraft a homing instrument to receive directional signals from radio beacons. The instrument could/~~had~~ have a fixed fixed loop antenna and could have been constructed for frequency selection during flight. This would have been sufficient to enable the pilot to orient himself by a radio beacon within his area of operations, and thus would have given him a fixed point for orientation. The G-5 instrument was suitable in every respect for such purposes.

The outcome of the failure to take any such steps in time was that the situation in 1940-41 made it imperative to establish a flight control organization for fighter units at the Channel coast and to use very inadequate means for the purpose. The solution adopted was the establishment of a special network of shortwave radio beacons operating on the voice radio frequencies of the fighter aircraft. From these radio beacons it was possible for a fighter pilot who had lost his way to obtain a fix.

This whole system was inappropriate for the following reasons:

(1) During good weather conditions of unobstructed ground visibility fighter personnel could orient themselves without any difficulty in an area they passed over daily, so that they needed no home radio beacon.

1565 (2) During bad weather there were usually a number of fighters returning from a mission with a very small fuel reserve who needed a fix. Since the radio beacons functioned on a system by which it was only possible to direct one plane at a time from outside units by means of indirect DF, to a landing, the whole organization necessarily failed whenever there was a rush.

The difficulties described above do not exist for planes with self-orientation equipment, since an unlimited number of planes can get their bearings from one beacon simultaneously and, supported by a fixed loop antenna and an optical indicator, each pilot can immediately set his plane on a course directly at the beacon until he has passed over it.

Throughout the war the fighter arm suffered under the results of this faulty concept of the principle of indirect DF operations.

When the Fu-G-7a shortwave instrument was displaced by the Fu-G-16 untrashortwave voice radio instrument, the fighter arm had an instrument which insured excellent reception of voice messages but did nothing to improve navigational possibilities. The shortwave radio beacons were admittedly converted to ultrashortwave frequencies, but the other inadequacies remained unchanged.

1566 The development of an airborne homing attachment for the Fu-G-16 for use with ultrashortwave radio beacons, and introduction of the new Fu-G-16-Z combined radio-direction finding instrument brought some improvement. The disadvantage of the new instrument was that it was installed in the tail and that the frequency had to be set before the plane took off from the ground. The pilot thus could only pick up signals from one radio beacon, operating on the frequency to which his instrument was tuned, and this was usually his base airfield.

1567 Since the effective range of all UKW instruments was governed by the "line-of-vision" principle, it could happen that a fighter operating far afield during unfavorable weather might find it impossible to pick up directional signals from "his" base beacon if he was flying at too low an altitude.

It is incomprehensible that the fighter arm continued to accept these disadvantages which caused frequent emergency landings and losses due to weather conditions because of false orientation. The reason was probably that the large majority of all German fighter pilots had no knowledge of radio navigation, a subject taught in the blind flying training course, and therefore knew nothing about its advantages. Furthermore, tendencies against any improvement were noticeable, since the

1567 improved possibilities of navigation, which would have made the fighter forces less dependent on weather conditions, would have resulted in an expansion of the by no means popular bomber escort mission.

The result of all these circumstances was that the development of fighter radio equipment in combination with development of the Benito control system, under strong influence by the Chief of Fighter Forces, remained based on the faulty principle of indirect DF operations (_Fremdpeilverfahren_). The whole system when completed represented an excellent technological solution and, owing to its numerous transmitting and receiving frequencies was practically interference proof. Again, however, it had the decisive disadvantage that one frequency could always only be used to track one plane, and that control immediately became technically impossible if a second plane inadvertently tuned in to the

1568 frequency on which the radar station was operating.

For use in the new system the Fu-G-16 instrument was adapted with a new Egon or Benito attachment (_Y-Zusatz_) and redesignated Fu-G-16-Y or in the case of instruments which also had the homing attachment, Fu-G-16-ZY.

The controlling ground network in this system required exceedingly large expenditures. Each channel used required one transmitter and one receiver, and the number of channels

1568 needed depended on the number of tactical fighter units whose operations had to be directed. Thus, if a fighter area (the command area of a fighter command or fighter division headquarters) operated on five channels it was possible to direct simultaneously not more than five tactical unitsfrom the size of a pair of aircraft to the size of a wing. Since the control range was contingent upon the altitude at which the aircraft were operating and upon a direct line of vision it was necessary to establish a network of these Benito fighter control positions covering the whole of Germany in order to insure uninterrupted controls.

Another disadvantage of the Benito system was that the unit commander had to rely on his box leader (Rottenfuehrer) to tune in to the radar station, since the messages from the radar station were on a frequency different to that to which his transceiver was set. The aircraft whose instrument was tuned to the radar station thus could receive voice radio messages from his unit and the directional signals from the ground, but was unable to transmit messages to his own unit.

One important disadvantage of this system of fighter control became particularly evident when the time came in the Home Air Defense Zone to commit a large number of group and wing size units simultaneously, frequently under difficult weather conditions. If, after an engagement, a unit was

1569 scattered over a large area above the cloud ceiling, the matter of station orientation became an acute problem for a large number of aircraft at one and the same time. If a number of them tuned in to the control station simultaneously, they had to be instructed to tune in one by one and revert to their normal frequency immediately after receiving a fix. This required firm discipline and took up much time, under conditions when discipline was somewhat shaken by a state of general nervousness and when a general shortage of fuel did not leave enough time to handle a large number of planes in succession.

Fighter personnel displayed a general lack of interest in radio operations and inadequate knowledge on the subject in general and of the proper handling of their Fu-G-16-Y instruments in particular. This frequently led to faulty functioning in the radar direction of complete units, so that the entire unit would fly around aimlessly owing to ignorance of its precise whereabouts and therefore could not be directed to the enemy.

As Chief of Fighter Command Holland-Ruhr Region the present author in 1942-43 participated intensively in the testing of the Fu-G-16-Y instrument, using a FW-190 and a Me-210 plane for the purpose. In all cases he found that the instrument functionaed with complete reliability if properly

1569 handled. The transition of a unit from control by one Benito station to control by another also presented no problem, provided the distance was not too great.

After fighter units had failed repeatedly in their missions because of malfunctioning of the Benito directing service, the present author personally carried out tests with other instruments on the basis of self-orientation. In these tests a combination of the Fu-G-120 "Bernhardine" instrument, which gave a fully autdmatic reading of the position line by untrashortwave beacons, and the Fu-Bl-2.E Bl-3 radio beacon landing instrument (<u>Bakenlandegeraet Fu Bl 2/E Bl 3</u>) proved the best solution and caused no special disadvantage so far as weight and space were concerned. The instruments were available in large numbers, having been produced formerly for the bomber forces, which no longer needed them. Six Bernhardine transmitterswere in operation within Germany and the occupied western territories in 1933 and were completely adequate to establish a position line throughout these areas at an altitude of 3300 feet. Two readingstaken from two separate stations in succession gave a cross reading which established the current position of a plane.

A test carried out showed the system to be absolutely reliable, and in the Spring of 1944 the present author used a FW-190 to demonstrate it to the Chief of Fighter Forces.

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1570 who, however, could not make up his mind to to further investigate the recommendation.

This lack of interest and lack of understanding can be explained only by the general attitude of rejection in German fighter personnel against operating conditions similar to those of multi-engine aircraft. Obviously it was believed that the two functions of flying and self-navigation would impose too severe a strain on the pilot of a single-seater fighter. That this was not the case was proved by American fighter personnel.

The failure to take this opportunity of giving fighter
1571 aircraft their own DF instruments was an indisputable error on the part of the Luftwaffe High Command, and an error which could have been avoided. The outcome in 1944 was a heavy toll of personnel and aircraft lost in missions flown during bad weather conditions.

The same mistake occurred when the jet fighter aircraft made its appearance: The Me-262 planes had Fu-G-16-ZY instruments. In view of the short time this type of plane could remain airborne, a homing instrument tuned to the radio beacon of its base airfield was useless when a fighter after a large area mission found himself compelled to land at some other airfield. It was not possible for the fighter pilot to select the frequency of some other airfield radio beacon while he was in the air.

1571 The pilot of a Me-262 had an additional complication to contend with, since he could only land at specific airfields which had a runway at least 1500 yards long if he intended taking off again from the same place. A landing at any other airfield due to fuel shortage was tantamount to an emergency landing and created the necessity to dismantle his plane and tow it to an airfield with a sufficiently long runway.

Since the enemy consistently planned the operations of their bomber forces in a manner which would compel the defending German fighters to operate under bad weather conditions, it would have been indispensable for the fighters to have navigational and landing instruments which would make them just as independent of weather conditions as the enemy bombers were. The only suitable system would have been that of self-orientation.

(2) Weapons. In line with experience from World War I, the armament adopted for the first German front line fighter aircraft, the Ar-65 and the He-51, comprised two Type 15 7.9-mm machine guns firing through the propellor disk and triggered by the crankshaft of the aircraft engine.

In view of the current methods of aircraft construction with unprotected fuel tanks, this gave the fighter completely adequate fire power to shoot down an enemy plane, particularly

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1572 since ammunition was already available with a tracer or phosphorus charge.

The sighting device used was the old ring-and-bead type sight introduced in World War I, which was fully adequate.

With a rope pulley the pilot operated the mechanical loading device of his machine guns.

The Bf-109-B and -C series showed an important improvement so far as their armament was concerned. Instead of the old type 15, the aircraft had type 17 machineguns of the same caliber but with a much higher rate of fire. Furthermore, each of these planes had three machineguns firing through the propellor disk and hub. The weapons were controlled electrically, and the guns had an electrical-pneumatic loading device.

This armament was exceptionally effective, since the guns were mounted centrally at the engine and therefore delivered a very concentrated cone of fire. One single burst of fire was usually sufficient to set an enemy plane on fire. Furthermore, the weapons functioned with absolute reliability.

The ammunition was in disintegrating belts, which disintegrated automatically as the cartriges entered the gun barrel, each section being ejected through a shaft into the air.

Planes of the Bf-109-D series had a new arrangement of weapons, with two type 17 machineguns mounted at the engine and one in each of the wings. However, the advantage accruing

1573 from the plane's increased fire power, because of its additional gun, was lost through the wider dispersion of its fire due to the wide spacing of its guns. The guns were adjusted to a range of 440 yards, and the wide dispersion was noticeable both at shorter and longer ranges.

In the Me-109-E series two type FFM 20-mm cannon took the place of the former two machine guns mounted in the wings, one in each wing. The 20-mm ammunition proved exceptionally effective against all types of targets. Here again the wide dispersion of fire resulting from the arrangement in which the guns were mounted in the wings proved a disadvantage.

All of the experience outlined above contributed towards adoption of what may be considered to have been the ideal solution at the time in the new Me-109-F series, which had one 20- or 30-mm cannon firing through the propellor hub and two type 17 machine guns mounted at the engine and firing through the propellor disk, which goes to show that a central mounting of the weapons had been accepted as the most effective arrangement.

The newly developed FW-190 in turn had four weapons mounted at the engine. To increase fire weight, the plane received larger caliber weapons, namely, two 13-mm and two type 151 20-mm machine guns.

With the appearance of the American 4-engine bombers

1574 came demands from the front line forces for still heavier fire power, since the heavy defensive fire of the bombers and their very effective insulation system against weapons fire compelled the German fighters to remain at a distance which was too great to achieve concentrated weapons fire on the target.

To meet this requirement fighters received two additional weapons, one in each of the wings. The Me-109 now had three cannon plus two machine guns, the FW-190 two 13-mm and two type 151 20-mm machine guns mounted at the engine plus two 20-mm guns in the wings.

The disadvantage of this solution was that the excess weight of the planes seriously reduced their climbing abilities and their maximum operating altitude. On the other hand the increased weapons fire did little to improve the effectiveness of the fighters, since the weapons mounted in the wings had a too wide field of dispersion when fired at too great a range.

Efforts continued unabated to achieve more effective fire power from greater distances for action against the American 4-engine bombers.

A special unit, the 25th Experimental Detachment, was organized for the sole purpose of carrying out tests to this end. The following are a few of the methods tried out

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1574 by the experimental detachment:

(1) Fightersflying above the bombers dropped 1100-pound bombs on the closely organized 4-engine bomber formations. After initial successes this method failed because the enemy increased their operating altitude to a level at which the FW-190 fighter could not achieve the necessary additional altitude while carrying a bomb. Furthermore, the weight of the bomb created the necessity to leave out the reserve fuel tank installed in the body of the plane, and without this the range of the FW-190 was too small.

(2) Hs-293 and Do-217 bombers took the bomber formation under fire with remote control rocket type bombs, with a fighter properly stationed to control the bomb ignition. These tests had to be abandoned in the initial stages because of the increased strength of the enemy fighter escorts.

(3) Fighters were given 210-mm smoke-shell mortars. Mounted in single- and twinengine daytime fighters and in night fighters as early as in 1943, this weapon proved the best solution. Fighters so armed achieved excellent results in encounters with 4-engine bomber formations operating without fighter escort.

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1575 When the enemy started sending their fighter escorts farther afield in 1944, however, this weapon also became practically ineffective, since it so far reduced the performances of fighter aircraft that they were definitely inferior to the enemy fighters in air combat.

Numerous other experiments were carried out with He-177 and Ju-88 bomber aircraft armed with type 36 210-mm smoke mortars mounted for vertical firing, or with 75-mm or 88-mm antiaircraft guns, but all failed because at the time when they were tried out the enemy fighters had already established air supremacy over the whole of Germany.

1576 All of the experiments carried out, however, ignored the real basic problem. No matter what the circumstances were, any FW-190 could have shot down any American 4-engine bomber if it had taken the bomber under accurately aimed fire with its four weapons at a range between 220 and 440 yards.

Developments in the armament of the Me-262 proceeded far more favorably. The possibility to mount the weapons in the turret of this twin-engine aircraft removed all difficulties otherwise encountered in efforts to secure a central mounting of the weapons. Its four 30-mm cannon gave this plane adequately effective fire power against any target.

Another supplementary weapon developed for fighters took the form of a new type of rocket, the R-4-M 50-mm rocket.

1576 These rockets could be mounted in brackets of twelve each, one bracket under each wing of the fighter. It was possible to fire the rockets in groups of six or twelve or in a single salvo of 24.

Aiming was relatively simple, since the rockets had a fairly flat trajectory owing to the fact that they were self-propelled. The maximum effective range was about 880 yards. On numerous occasions a single salvo of R-4-M rockets was sufficient to bring down a number of enemy bombers.

The results obtained with this new weapon proved that it was the best solution to the problem of supplementary weapons for fighters operating against 4-engine enemy bombers. However, this development came too late, since it was no longer possible to arm the bulk of the Me-109 and FW-190 fighter units with the new rocket.

(3) Single-Engine Daytime Fighter Production. At the time when the decision was taken to establish the Luftwaffe as a third and separate branch of the military forces in 1933, only a few small industrial works were available for the manufacture of aircraft. Some of the firms involved, namely, Heinkel, Junkers, Focke-Wulf, and Dornier had kept pace with developments after World War I owing to the necessity to compete against foreign firms in the manufacture of military and commercial types of aircraft. Other firms had confined

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1577 themselves to the manufacture of sport and school aircraft and smaller types of commercial planes, as was the case with the firms of Messerschmitt (BFW), Fieseler, Klemm, and Albatross.

That the first fighter models, the He-51 and Ar-65 could be placed in serial production so soon was only possible after the Government had renounced the principles of free competition and had specified other factories to manufacture the two models under licence, granting the firms thus designated financial support to expand their existing factories for the purpose.

In line with the decision to place main emphasis on the bomber arm, the scope of fighter production initially was not large. However, it was nevertheless adequate to meet the requirements for the supply of aircraft to the fighter units to be activated under the established activation program. From the outset the whole arrangement was of a provisional nature designed to cover the period until the necessary factories for manufacture of the Bf-109 fighter model could be
1578 established. The course thus adopted was pursued with the dynamic energy characteristic of the Third Reich.

In spite of all that was done, however, the evolution of the tactical concepts of the Luftwaffe concerning the missions of a fighter arm contained in its computations a serious error which was only to become evident later in its effects. This

1578 error was the inclusion of the Bf-110 "heavy fighter" in the fighter aircraft production program. The share of the fighter production facilities allocated to this type was quite considerable, since out of the final strength of 7 500 fighter aircraft planned for 1 April 1942, 3 200 were to be "heavy (twin-engine) types. Original plans provided for the Bf-110 to be powered by two Jumo-210 engines, but this model proved a failure. The considerably improved Bf-110-C powered by two DB-601 engines only became available in 1939, when production of the DB-601 engine in large series became possible.

This meant that the initial program for twin-engine fighter aircraft could not be fulfilled, so that a large number of the planned twin-engine fighter units had to be equipped with the Bf-109 aircraft intended for the single-engine units.

This in turn upset the whole program for the activation of 13 light fighter groups on 1 November 1939, which date was advanced by mobilization measures for only a few of the units, while the majority of them were not activated at all.

Taking into consideration the monthly output of only 112 Bf-109 aircraft in the months of September through December
1579 1939 and of only 141, on an average, in 1940 it becomes evident that the armament basis for the fighter arm was actually too small prior to and at the beginning of the war.

1579 It is obvious that the Luftwaffe High Command did not give due consideration to this fact. Even though General Jeschonnek, at the time Chief of the Luftwaffe General Staff, still held the opinion in 1941 that a monthly output of 360 aircraft would be sufficient to maintain the fighter arm, it can be stated that a comparative examination of the authorized, actual, and operable aircraft strengths of fighter forces in 1941 definitely would have resulted in a different appraisal of the armament situation in 1941 so far as the fighter arm was concerned. Cold figures prove incontrovertibly that the replacement aircraft and spare parts furnished at the time were by no means adequate to even approach the authorized strengths.

It was only after Field Marshal Milch assumed responsibility for the direction of armament activities following the death of Chief of Special Supplies and Procurement Udet, that the armament basis for the fighter arm underwent a radical change.

The concepts of Field Marshal Milch, as propounded by him before the Industrial Council (<u>Industrierat</u>) on 18 August 1941, were governed by the following factors:

(a) An increased output is essential for the maintenance of the existing fighter units.

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1579 (2) Since no new aircraft type will be available in mass production for the fighter arm by 1942-43, it is necessary to manufacture the old and tested types in large numbers for those years.

(3) For this purpose it will be necessary to have a monthly output of

200 Me-109 and

170 FW-190 as an initial figure to be increased to 485 with a concurrent decrease in the output of Me-109.

Events showed, however, that it was no easy matter to make up for the time lost in 1939-41 in the build up of the fighter arm.

The average monthly output of 366.5 fighter aircraft achieved in 1942 was barely more than the figure of 360 per month originally approved by General Jeschonnek. Within this figure the average monthly output of FW-190 reached the figure of only 160 planes and was thus far below the figure established in plans by Field Marshal Milch on 18 August 1941.

It was 1943 before the measures introduced by Field Marshal Milch to step up the production of fighter type aircraft showed tangible results. It was in that year that fighter production reached the highest monthly level, with an output of 704 Me-109 in July, and of 313 FW-190 in December

1580 The overall peak was reached in July of the year with a total of 873, namely Me-109 and FW-190 together. This overall figure dropped again later in the year as a result of the damage done by enemy air attacks.[797]

From the above it can be seen how exceedingly difficult
1581 it is to adapt production planning properly to future requirements. All measures taken to step up production need time to take effect. On the other hand, any computation of future need will be subject to a number of unknown factors, such as developments in the military situation, future losses, the effects enemy attacks might have on the armament industry, and the future availability of man power and materials, none of which can be estimated with any degree of accuracy for any length of time in advance.

In one case the Luftwaffe endeavored to remove the factor of uncertainty. This was by moving aircraft manufacturing installations to localities where it could be assumed that they would be safe against enemy air attack.

Measures of this nature were first taken in 1943 as a result of the first noticeable interruption of air armament operations due to enemy air attacks. The whole project involved immense expenditures in man power, materials, and time, However, the steps thus taken did produce satisfactory results although it was not possible to carry out the project to the

797. Source 138.

1581 necessary extent by the end of the war.

Here again the big mistake was that the project was not started sooner on the basis of long-range appraisals of the possibilities open to the enemy. That the Americans were building up strong air forces in Britain was known as early as in the spring of 1942. It was also known since August 1942 that the bomber forces thus being built up were not intended for participation in the night air warfare conducted by the Royal Air Force, but would follow their own strategy and tactics in daytime precision bombing attacks against factories of the German armament industry.

The German factory-transfer project was only given the highest priority when the seriousness of the situation became unmistakably clear to all German command authorities after the Anglo-American "Big Week" of air attacks against German factories manufacturing fighter aircraft in February 1944.

The first purpose for which the Fighter Production Staff was established on 1 March 1944 was to take speedy and comprehensive measures of the highest priority to expedite the transfer of fighter aircraft manufacturing installations. The next item on the program of the staff was to work out a fighter manufacturing program aiming at a speedy increase in the monthly output of fighter type aircraft.

1582 The successful outcome of these measures was that in September 1944 fighter aircraft production reached the record level of 1575 Me-109 and 898 FW-190 planes, all for exclusive allocation to the daytime fighter units.

This performance is marvellous proof of the excellent organizational ability of the Fighter Production Staff and of the work done in the armament industry, particularly in consideration of the fact that it was achieved at a time when the enemy had absolute air supremacy over the territories in which the armament factories were situated.

From the outset, however, all of these efforts were subject to the one cardinal flaw in the whole concept. All the efforts and work involved were expended on an unsuitable means, namely on obsolete types of fighter aircraft and were thus wasted, since these aircraft could never serve the desired purpose of regaining air supremacy over Germany--in the Home Air Defense Zone.

When this error was finally realized and the highest priority was assigned to the production of aircraft on an entirely different plane of performances, the Me-262 and the He-162, in the autumn of 1944, the military situation had deteriorated to such an extent that all efforts now expended in this direction were illusory.

1583 1. Twin-Engine Fighter Aircraft Production.

a. Operating Range. The idea of a heavily armed, long range "heavy fighter" for all-weather operability evolved in the Luftwaffe initially from concepts of the necessity for a type of fighter plane which could be used within large areas to form air defense power concentrations. From 1938 on, however, emphasis shifted to a concept in which the primary mission of "heavy fighters" was to support aggressive air forces by furnishing fighter escorts to protect bomber units on their missions. This is why development specificatuons required a penetration range of 600 miles, which corresponded to the penetration range of bomber aircraft.

The first "heavy fighter" model, the Bf-110-B, had two Jumo-210 engines which gave it a time-in-air capability of 4.5 hours at a touring speed of 240 miles, so that it did not quite meet the specified penetration range of 600 miles. The Luftwaffe nevertheless decided in favor of this plane because no better solution could be found and because the performances of the plane were considered adequate under the conditions existing at the time.

The Bf-110-B was only between 18 and 24 miles slower than the Bf-109 with its Jumo-210 engine but was more maneuverable.

1584 The outcome of the excessive demands made on the manufacturing capabilities of the firm of Messerschmitt to meet the full requirements of the Luftwaffe for Bf-109 and Bf-110 aircraft was that measures to put these two models into serial pwoduction were delayed beyond the deadlines established in the armament program. It was 1939 before the first Bf-110 planes reached the troops, roughly four years after the decision to place this model in serial production.

During these four years engine development had progressed from the 700 horse power of the Jumo-210 to the 1100 horse power of the DB-601. The new engine also had important advantages in the matter of its full-pressure altitude performances and in its automatically adjusting fuel pressure pump. The improved performances of the Bf-109 and Bf-110 with the new engine were so pronounced, that the DB-601 was adopted to take the place of the Jumo-210 in fighter aircraft.

In the case of the Bf-110 fighter the bigger fuel consumption of the two DB-601 engines brought about an appreciable reduction of the planes overall time-in-air capability.

Operating at the maximum duration fuel feed pressure of 1.15 of absolute atmospheric pressure (16.1 pounds), with 2 200 revolutions per minute, at an altitude of 13 200 feet and a speed of 291 miles, the plane now had a time-in-air capability of 110 minutes or an overall duration flight

1585 capability of 506 miles. Under economy cruising conditions, with the fuel feed at 0.7 of absolute atmospheric pressure (9.8 pounds), 1600 revolutions per minute, and a speed of 205 miles at an altitude of 13 200 feet the new time-in-air capability was 3 hours and 35 minutes and the non-stop flight performance 744 miles.

The average time-in-air capability during operations was around 2 hours and 45 minutes. Deducting 30 minutes for air combat and 20 minutes for landing operations, the BF-110-C had a tactical non-stop flight performance of 1 hour and 50 minutes, so that its maximum penetration range was 228 miles. This was the practical outcome of the initially stated specifications requiring a penetration range of 600 miles.

In view of the concepts of the Luftwaffe on the future tactical missions of "heavy" or twin-engine fighter units as escort aircraft to protect the operational forces of the bomber arm it would have seemed reasonable to expect immediate measures to increase the fuel supply which the Bf-110-C could carry. What should have made the introduction of such measures all the more urgently important was that the Luftwaffe High Command in 1939 cannot have entertained any doubts after the experience gained in the Spanish Civil War that an economical use of bomber forces against targets far inside

1585 enemy territory was only possible if the bombers were protected by escort fighters, so that the penetration range of these escort fighters, in this case 228 miles, represented the maximum operational range of the bomber forces.

The possibility exists that the Luftwaffe High Command in 1939 considered such limitations acceptable, since military planning initially only envisaged a solution of the German minority problems in Poland and the removal of the Polish Corridor in order to bring separation of Eastern Prussia from the rest of Germany to an end.

1586 Once Britain and France had declared war against Germany on 3 September 1939, however, the need to increase the range of the Bf-110-C became a matter of currently urgent importance. However, nothing was done in this direction.

The failure to take any such steps had no serious consequences in the 1940 campaign in the west, since the opposing forces there collapsed within an astonishingly short time without the necessity for long-range air warfare against targets within the enemy interior. However, on the second day of the campaign a bomber group operating without fighter escort against targets within France and at a distance of only 60 miles lost 28 of its 30 bombers, all brought down by enemy fighters. This incident should have sufficed to cause the German Command to give matters careful consideration in view of

1586 of the air operations intended later against Britain.

If the German side had been able to commit nine twin-engine fighter groups with a penetration range of between 360 and 420 miles, enabling them to protect bomber forces operating against targets in the British interior to a line level with Edinburgh and Glasgow, this would have provided a far wider scope for the German concept of strategic bombing and would have created problems incomparably more difficult for the British defense.

The question arises here whether such an increase in the penetration range of the Bf-110-C was possible. The answer mus be in the affirmative, since the troops in the field in 1941 found a solution which was technically sound in every respect by mounting a 300 liter (79.22 US gallon) reserve fuel tank under each wing, thereby increasing the time-in-air capability
1587 of the plane by a full hour.

While serving in an assignment as CO, 76th Twin-Engine Fighter Wing in Norway in the winter of 1941-42, the present author personally tried out the plane with its two 300-liter reserve fuel tanks repeatedly on non-stop flights of 840 miles, and with two 900 liter (237.66 US gallon) reserve tanks on a

1587 non-stop flight of 1200 miles on the Stavanger-Kirkenes route. The pattern of these tanks was then taken over by the manufacturers, as developed by the headquarters staff of the 76th twin-Engine Fighter Wing, for serial production.of the Bf-110.

This shows that a technically sound solution of the problem of reserve fuel tanks for the Bf-110 was possible as early as in the winter of 1939-40, and that it could have been put into effect in the summer of 1940 for the air offensive against Britain.

In the air offensive against Britain there was no possibility to take advantage of the actual full penetration range of 208 miles which the Bf-110-C had because all operations had to be planned on the penetration range of the Bf-109 units in order to have the necessary strengths available for escort purposes. This restriction on the operating scope of the German bomber forces made it easier for the British defense to concentrate its defense fighters within the areas involved and in the final essence was the cause of the complete failure of the German offensive.

In the autumn of 1940 the large bulk of all twin-engine fighter units were transferred to the night fighter arm and it was only in 1943 that some of them were again committed in their originally intended mission of home daytime air defense after the 26th and 76th Twin-Engine Fighter Wings hade been

1588 activated, or reactivated.

These two wings received Me-110-G planes, the performances of which had been improved through its DB-605 engines. The initial intention to equip the wings with Me-210 planes had to be dropped since the restrictions imposed on the designer of this plane by the requirement that itwas to serve the dual purposes of a fast bomber and a dive-bomber had resulted in the complete failure of the plane as a fighter.

The overall tim-in-air capability of the Me-210 with its two Jumo-211 engines was 3 hours and 40 minutes at a cruising speed of 276 miles at an altitude of 13200 feet . This gave it a penetration rangeof between 390 and 420 miles on tactical missions. The development specifications had required an overall non-stop flight performance of 1500 miles giving it a tactical penetration range of 600 miles. The stated specifications were thus not met by the Me-210 so far as operating range was concerned.

With the changeover from Jumo-211 to DB-603 engines precisely the same happened in the case of the Me-410 as in that of the Bf-110-C: the larger fuel consumption of the new type of engines decreased the plane's non-stop flight capabilities by a full hour, and nothing was done to offset this disadvantage by the installation of reserve fuel tanks.

1588 In 1943-44 the twin-engine fighter units of the Home Air Defense System were reequipped with Me-410 aircraft. At this juncture the question of range capabilities was of no consequence, since the overall nonstop flight capabilities of the Me-410, 755 miles, was adequate under any circumstances for

1589 the purposes of home air defense.

The fact that neither the Me-110-G nor the Me-410 aircraft could turn the twin-engine fighter forces into a decisively important component of home air defense was not due to range performances but to the circumstances that these aircraft were too inferior in their general flight and other technical performances to the P-47 and P-51 fighter types used by the Allies in escort missions. The Luftwaffe had great hopes that good results could be achieved with the Ta-154, a plane under development as a copy of the British Mosquito type and designed as a long-range and high performance twin-engine fighter. However, the project did not progress beyond the construction of a few test models and had to be discontinued in 1944 owing to the inadequate factory facilities available.

Another promising project was that of the Do-335, also intended as a variant of the twin-engine fighter type. However, this project started too late and therefore could not be completed before the end of the war.

1589 Both the Ta-154 and the Do-335 would have had an operating range adequate for all home air defense purposes.

From the viewpoint of air defense it can thus be established that the Luftwaffe in its Me-110 and Me-410 models had heavy fighter aircraft available which were not in all respects suitable for large-area all weather operations against enemy bomber forces operating under fighter escort.

From the operational viewpoint these aircraft were unsuitable in every respect because they lacked the necessary range capability for use as escort fighters for bomber forces on strategic missions.

a. General Flight Performances of German Twin-engine Fighter Aircraft. As he had done with his Bf-109 in the case of light fighters, aircraft designer Messerschmitt with his Bf-110-B, as the first "heavy fighter" developed in Germany, achieved a decisive lead over the types developed abroad, such as the Potez 63 and the British Beaufighter.

The Me-110-B had a maximum speed of between 230 and 244 miles. The Me-110-C achieved a speed of 303 miles at an altitude of 16 500 feet, and was thus considerably faster than the most up-to-date French Morane 406 single-seater fighter and the British Hurricane. In a flat glide and in dive performances it was even faster than the British Spitfire.

1590 An interesting feature discovered in air contests between Me-110 and British and French fighters at the western borders of Germany early in 1940 was that the Me-110 was equal to the enemy planes even in its curving properties. In curving maneuvers only the Spitfire proved superior, since it could climb so fast in a curve that the Me-110 fighter found no opportunity to shoot it down.

This served to show that with its two-seater Me-110 "heavy" fighter the German side had achieved a slight lead over foreign modern developments in the field of single-seater, single-engine fighter models.

However, knowledge of the general principles of aerodynamics, physics, and tactics should have made it perfectly clear from the outset that this lead could not last long, Given even only approximately equal technical perfection, a single-engine, single seater fighter plane, necessarily would be superior to its twin-engine two seater counterpart. It should have been clear that the two-seater fighter would fail in its mission of serving as a long-range fighter escort for bombers operating over enemy territory immediately the enemy succeeded in placing a technically equal single-seater fighter in operation.

With their Spitfire, units of which were already in action during the 1940 campaign in the west, the British

1591 had not only made up the lead hitherto held by the Me-110 in general flight performances, but had even achieved superiority in climbing and horizontal speeds.

A new lead over the single-seater, single-engine types was only established by the light wood structure of the twin-engine Ta-154, and the new engine alignment of the Do-335, which gave the fuselage of this plane the dominant features of a single engine model. By this time, however, a stage had been reached at which it was obvious that this lead could not be held for long, since foreign powers were already developing jet driven fighters, thereby entering a field with an entirely new level of performances.

From the viewpoint of flight performances, the continued development of the twin-engine fighter, in the form of the Me-210 and Me-410 variants, therefore must be considered to have been a faulty procedure, inasmuch as it was known that these would have to contend against single-seater aircraft developed on the single-engine principle. This would apply unavoidably ~~xxxxxxxx~~ whenever twin-engine fighters engaged in strategic missions encountered defending single-engine fighters of equal quality, and whenever they were employed in air defense missions against bomber forces escorted by

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1592 single-engine fighter units.

It would have been more sound to adopt the course adopted by the Americans of increasing the radius of action of single-engine fighter models by the installation of reserve fuel tanks in the wings as required.

c. Twin-Engine Fighter Aircraft Equipment.

(1) Radio Equipment. The Bf-110 as the first German twin-engine fighter placed in service, had the following radio equipment:

Fu-G-10 for shortwave telegraph and voice communications

Peil-G-5 for navigation by radio beacons and self-orientation

Ei-V for communication between the pilot and the radio operator

Fu-Bl-2 with E-Bl-2 attachment for landing by ultrashortwave radio beacon orientation during bad weather.

This equipment can be considered as a perfect solution for all radio technical problems involved so far as twin-engine fighters were concerned. Using the directional signals from heavy ground radio beacons to establish a position line it was possible to designate a meeting point with the bomber force to be escorted over any area without regard for ground visibility conditions. Using their Peil-G-5 instruments the

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1593 individual planes of a unit could climb through a closed cloud ceiling and then reassemble by the directional signals transmitted by the lead plane without any difficulty. The Peil-G-5 instrument also made precise steering by any radio beacon possible as well as by any radio broadcasting station, using the spiralling method in both cases. This gave the planes complete safety when it was necessary for them to descend through dense low-hanging clouds before their landing run.

The ability to land by ultrashortwave radio beacons enabled the units to carry out their landing maneuvers without any need for ground controls.

The only real disadvantage in the initial radio equipment was that air-air communications with the Fu-G-10 instrument on shortwave frequencies was subject to atmospheric interferences. This made communications difficult and impaired proper control of the unit while airborne. For this reason the Me-110 units later received Fu-G-16 untrashortwave instruments, which insured uninterrupted air-air and air-ground voice communications at all times.

The radio equipment described above having proved satisfactory in the Me-110, it was adopted as standard equipment, and was also installed in the Me-210 and Me-410.

It can thus be stated that the radio equipment of the

1593 It can thus be stated here that the radio equipment of German twin-engine fighter aircraft was well considered and that it met all requirements.

(1) Armament of Daytime Twin-Engine Fighter Aircraft

Peacetime tests had already shown that the central position of the four type 17 7.9-mm machine guns and two 20-mm cannon in the turret gave the Bf-110 exceedingly effective fire power. The parallel trajectories of the six weapons gave each burst of fire an annihilating effect if the gunner hit his target. This system of gun emplacement was retained in all later models.

In operations against the American 4-engine bombers in 1943, the heavy defensive fire of these new enemy aircraft and the fact that its size made the Me-110 a vulnerable target created the urgently important problem of large caliber weapons for effective fire at a greater range.

Two solutions were put into effect:

(a) A 50-mm antiaircraft type gun

(b) Two 210-mm mortars, one under each wing.

The 50-mm antiaircraft type gun proved a failure since the heavy additional load it represented ~~since it~~ reduced the maximum altitude at which Me-110 and Me-410 aircraft could operate in units to 23 000 feet, so that such units were unable ~~to operate against~~

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1594 to operate against American 4-engine bomber forces operating at altitudes up to 30 000 feet.

In contrast, it was the 210-mm smoke mortar which enabled the units of the 26th and 76th Twin-Engine Fighter Wings com-
1595 mitted in home air defense to achieve such excellent results results in 1943.

In addition to its rigidly mounted weapons with a forward field of fire, the Bf-110 had a type 15 machine gun on a swivel mount with a rearward field of fire and operated by the radio operator. Initially this gun was mounted on a circular gun track. In order to operate it the radio operator had to open the cabin, and since this reduced the plane's speed by 18-24 miles this arrangement was definitely not suitable. After the Polish campaign the troops themselves built in a pivot mount enabling the operator to fire from the closed cabin. This solution proved so satisfactory that it was later included in the serial production of the plane. On numerous occasions the radio operator succeeded in downing pursuing enemy fighters with his rear gun.

The Me-210 had an extremely complicated arrangement for rearward defense, with two 13- or 15-mm machine guns mounted on the two sides of the fuselage and wired for electrical firing. However, this arrangement involved such a heavy

1595 extra load that it was soon discontinued.

On the whole it can be stated that twin-engine fighter aircraft had exceedingly effective fire power, adequate for all purposes as long as developments on the enemy side permitted the use of these weapons at ranges up to 660 yards. When the appearance of the American 4-engine bomber made it necessary to increase the effective range of the fighter-carried weapons in order to reduce the hazards for the twin-engine fighter, rocket propelled missiles proved the only possible solution. All other types of larger caliber weapons increased the weight of the fighter too seriously and thereby seriously reduced its flight performances.

d. Production of Daytime Twin-Engine Fighter Aircraft. As in the case of the Bf-109 the necessity to increase the manufacturing capacities of the Messerschmitt Works also resulted in a delay in putting the Bf-110 into serial production. This made it impossible to equip the twin-engine fighter units with Bf-110 aircraft by the established deadlines.

Taking into consideration that of the ten twin-engine fighter groups in existence at the beginning of the war only three had Bf-110 aircraft, while the rest were equipped with Bf-109 planes, and in view of the great importance attached to this weapon for the conduct of operational air warfare, it

1596 must be said here that Luftwaffe planning was extremely faulty. However, this faulty planning produced no immediately serious consequences since the striking range of the Bf-109, and particularly of those groups still equipped with the aircraft from the Bf-109-D series, was adequate for the strategic objectives of air warfare against Poland.

1597 The tangible results of the delayed production of Bf-110 aircraft only made themselves felt later during the air offensive against Britain in the summer of 1940.

At the beginning of the 1940 campaign in France the twin-engine fighter units received aircraft allocations adequate to bring each group up to an average strength of 25 aircraft--compared with the authorized group strength of 39. Throughout the campaign the units received no replacement aircraft and even after the campaign the inadequate number of Me-110 aircraft coming from current output made it impossible to bring the units up to full authorized strength. The twin-engine fighter groups started their operations in the air offensive against Britain in July 1940 with aircraft strengths ranging from 25 to 30 aircraft.

On 28 September 1940 actual strength in twin-engine fighter aircraft was 66 percent of the authorized figure, the operable strength 62 percent of the actual or 42 percent of the authorized figure. Only completely inadequate manufacturing

1597 resources could have produced a situation such as this.

Taking into consideration that on 1 September 1939 seven twin-engine fighter groups were still waiting for equipment with Bf-110 aircraft, that the average monthly output from September to December 1939 was only 39 aircraft or just enough to equip one group, and that between 1 January and 1 July 1940 the average monthly output remained at not more than 79 aircraft, it is obvious that the current output could never be adequate to meet requirements for initial unit equipment and at the same time replace the losses occurring from the moment war commenced.

In spite of the large requirements for both daytime and night twin-engine fighters in 1941, current output in that year dropped to an average of 65 aircraft of the Me-110 type in that year and dropped to an absolute low of 48 per month

1598 in 1942.

Requirements for Me-110 aircraft increased in 1943 because of the activation of the 76th Twin-Engine Fighter Wing and because twin-engine units were again used in daytime home air defense action, requirements which had to be met in addition to those of the night fighter arm. Again current output made only an inadequate increase, so that allocations in Me-110 aircraft could only be made to the daytime forces at the expense of the night fighter arm or vice versa. Owing to the

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1598 inadequate number of Me-110 aircraft available it was also not possible to activate the 9th Squadron of the 76th Twin-Engine Fighter Wing, and again because of aircraft shortages the wing's 3d Group had to be deactivated prematurely on 1 April 1944.

Another complicating factor was that the decision to equip reconnaissance units with Me-110 type aircraft created an additional user of this type.

The faulty planning for production of Me-210 and Me-210 and Me-410 aircraft revealed by the circumstances discussed above is all the harder to understand when the fact is taken into consideration that no plans existed at any time for the development of some other model which could have been made available soon for allocation to the twin-engine fighter forces.

Through this neglectful planning the Luftwaffe forfeited the possibility to base its air defense on strong twin-engine fighter forces in all cases when enemy bombers operated during daylight without fighter escorts.

It can be assumed that in 1942 a German home air defense system based on twin-engine instead of single-engine fighter forces might have proved far more effective against operations by American 4-engine bomber forces because of the large-area capabilities of twin-engine fighter aircraft.

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1599 Finally, the Fighter Production Staff established in March 1944, with the mission of stepping up fighter aircraft production to maximum performances as speedily as possible, made no special provisions for an accelerated production of twin-engine fighter aircraft. The plans of this staff included the requirements of the daytime twin-engine fighter forces in the production program for the night fighter arm. The reason here was obviously that by this time twin-engine fighters in daytime operations had already been relegated to the role of a reserve force for action against ~~enemy~~ bombers which had succeeded without fighter escorts in penetrating the perimeter defenses. The usefulness of the twin-engine fighter came to an end when the American side placed in service their P-51 Mustang escort fighter, which had a range adequate to cover the whole of Germany.

For the above reasons it can be considered as an established fact that failure on the part of the Luftwaffe to develop adequate manufacturing resources for thw twin-engine fighter arm from the outset hampered the free development of this arm and made it impossible for the twin-engine fighter forces at any time during the war to participate effectively in operational air warfare by protecting German bombers or in the air defense mission.

1600 3. Night Fighter Aircraft.

a. Operating Range. At the time when the Luftwaffe General Staff on 28 April 1937 issued orders for large-scale experiments in night fighter activities, the decision as to what type of aircraft to use for the purpose was premised on the assumption that the night fighter mission could be accomplished by the standard types of aircraft used in daytime operations.

The standard models used to equip daytime fighter units at the time were the He-51 and the Ar-68, and even for pilots without training in night blind flight night operations with these models presented no problems since their operations remained confined within relatively small areas and conditions at that time made night operations, both for an attacker and for a defending force, dependent on good visibility conditions.

Even the plans for a later reequipment with Bf-109 aircraft seemed to present no problems for night fighter operations, and experiments with this model were included in the test program.

The time-in-air capabilities and radius of action of daytime aircraft were definitely adequate for the execution of the direct target defense mission.

1600 A point not taken into consideration, however, was that the total number of single- and twin-engine units available
1601 definitely provided no guarantee that adequate strengths would be available for both the aggressive and defensive air mission, to furnish escort protection for German aggressive bomber forces, and at the same time accomplish the air defense mission during daylight and at night.

For this reason it would have been more sound prior to the war to develop a special aircraft type for night fighter purpose, which could have been produced without placing any strain on the Messerschmitt production program.

When the establishment of a night fighter arm for home air defense became a matter of current importance in the summer of 1941, it was therefore necessary to draw on the resources available in the current serial production of fighter aircraft types. The types decided upon were the Me-110 for close-range and the Ju-88 for long-range night fighter purposes.

It was a fortunate circumstance that the transfer of the bulk of all existing daytime twin-engine fighter units to the night fighter arm averted an all too great additional burden on the Me-110 manufacturing resources. The procurement of Ju-88 aircraft for the night fighter arm was a difficult matter since this was the standard bomber model and since a number of

1601 bomber units were still waiting to exchange their He-111 for Ju-88 aircraft. However, it was the only possible solution since no other suitable aircraft model was in production for night fighter operations.

The Me-110-C had a non-stop flight capability of 2 hours and 40 minutes. In 1941 its performance was increased by a full hour through two reserve fuel tanks of 300 liters (roughly 80 gallons) each, and this met all requirements for night fighting. Even after the changeover to DB-605 engines in the Me-110-G series, which deprived the plane of its added one hour of non-stop flight capability, it was still adequate for night fighter purposes at that time.

When British tinfoil interference tactics in the summer of 1943 compelled the German side to adopt the systems of direct target defense and night fighter pursuit operations, and when the British at the same time commenced planning their attacks to coincide with bad weather conditions over the target area, the overall non-stop flight capability of the Me-110-G, which was roughly three hours, was no longer adequate for the exploitation of all possibilities for defense action under the new circumstances. In the case of an attack by Royal Air Force units against Munich, for example, Me-110 night fighters taking off from air bases in Holland to participate in the defense action used up two-thirds of the fuel before even

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1602 reaching the target area, and then did not have enough fuel left to reach an airfield where weather conditions were favorable for a landing or to return to their own bases. In such cases the units involved found themselves compelled by their inadequate range to break off an engagement prematurely.

The situation was entirely different with the Ju-88. This plane could stay 4½ to 5 hours in the air and therefore could master any situation arising in connection with night fighter defense action. The range of this plane was also adequate for long-range night fighter operations over England and over the Mediterranean Sea, including an adequate fuel supply for a safe landing. As it was the crew members could not be expected to bear up under the concentrated tension of pursuit action against enemy planes anyhow for longer than 2 to 2½ hours.

What has just been said of the Ju-88 applies equally to the Do-217, which was also used periodically in night fighter operations.

The Do-219 was designed from the outset for a non-stop flight performance of 4 to 4½ hours and in this respect met all requirements for night fighter operations. Owing to its greater speed it achieved the same penetration range as the Ju-88.

Designed specifically for action against British Mosquito

1603 aircraft, the Me-410 can be considered equal to the Me-110-G so far as its striking range was concerned. Since it was used exclusively in controlled night fighter operations, its flight duration was completely adequate. With a greater penetration range, however, the Me-410 would have presented particularly favorable opportunities for long-range night fighter operations against targets in Britain, since it was almost as fast as the British Mosquito plane, so that the British would have found it more difficult to hunt it down than was the case with the Ju-88 and the Do-217.

Towards the end of the war the Me-262 was also employed in night defense action against British Mosquito units. This plane had only a 50-minute duration flight performance. This gave it a far too small radius of action so that it could only be committed in limited missions during good weather and only in direct target defense action where it could find adequate landing and take-off runways in the immediate vicinity. Owing to this limited range of the Me-262 a large number of such units would have been necessary to provide protection for all important targets taken under regular attack by British Mosquito forces.

The single-engine night fighter arm had to make use of the standard aircraft types used in daytime operations, the Me-109 and FW-190. These had a flight duration performance

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1604 of between 2 and 2½ hours with their two 300 liter (roughly 80 gallon) reserve fuel tanks and were therefore adequate for the originally planned tactics when the weather was favorable. However, developments in the air situation were such that the single-engine night fighters usually had to operate under unfavorable weather conditions and had to cover a long approach route before going into action. For such purposes the Me-109 and FW-190 were completely unsuitable, since far more time had to be allowed for their ground controlled take-off and landing operations than was the case with twin-engine night fighter units. Very often this circumstance was not taken into consideration in the commitment of single-engine night fighter units, and the consequence of such neglect was that many planes were lost owing to weather conditions. Finally the frequency of such losses rendered the whole commitment of single-engine aircraft in night defense uneconomical and necessitated discontinuation of such operations.

The following lessons can be learned and experience deduced from the subject of the operating range of German night fighter aircraft:

(1) Of the aircraft types initially employed in night fighter operations only those taken over from the bomber arm met all requirements so far as the problem of striking range was concerned.

1604 (2) The aircraft types taken from the single-engine daytime fighter forces suffered under the same disadvantage of too small radius of action in night operations as had been the case when they were employed in daytime defense.

(3) It is always a disadvantage if a specific arm has to depend for its equipment on a type of aircraft intended primarily for allocation to some other arm, unless the additional requirements thus created are properly included in the computations of well-considered planning.

(4) The only aircraft type which completely met all requirements for night operations, including an adequate striking range, was the He-219, specifically designed and developed for this specific purpose.

That the efforts of the Night Fighter Command to have all night fighter units reequipped with this type failed must be considered as a definite failure on the part of Luftwaffe armament programs.

(5) A non-stop flight performance of between 4 and 4½ hours, including approach and return flight, is commensurate with the permissible endurance, physically and psychologically, of the crew in night fighter combat.

b. Aviation Performances of Night Fighter Aircraft. In the matter of the aviation performances of aircraft intended for night operations the following can be considered

1605 as the most important factors contributing towards successful action:

(1) Good climbing ability in order to achieve speedily the approach altitude of the enemy force.

(2) A speed advantage of 30-40 percent over the enemy aircraft plus quick acceleration to insure a speedy approach to within visual contact with the enemy.

(3) High maneuverability in order to be able to follow defense maneuvers of the enemy.

(4) Good all-weather take-off and landing ability, with a minimum of visual aids, in order to complicate enemy long-range fighter action designed to prevent such take-off and landing operations.

In an appraisal of the capabilities of German night fighter aircraft, the capabilities of the bomber aircraft of the enemy conducting night operations, and thus primarily of the Royal Air Force, must be taken as a standard.

The British in their night operations initially employed Wellington, Blenheim, and Whitley twin-engine bombers, with the Wellington type predominating. The Me-110 aircraft at that time in service in the German night fighter arm were so pronouncedly superior in their performances to these British types that they met all requirements.

1606 The changeover by the Royal Air Force to the 4-engine Halifax, Stirling, and Lancaster types gave the British bomber forces increased speed and an increased operating altitude. The speed advantage of all German twin-engine night fighter aircraft nevertheless remained large enough to maintain their character as fighters. Their maneuverability was also adequate enough for action against the 4-engine bombers, which were relatively heavy in handling because of their size.

Only the Ju-88-A4 planes with their Jumo-211 engines and the Do-217 showed signs of too slow acceleration in the Himmelbett waiting tactics employed on the German side. In such operations it was important for the plane released for action to establish visual contact with its assigned target as speedily as possible. Otherwise the target and the fighter left the range of the controlling Wuerzburg instruments, so that ground control was no longer possible.

The flight performances of the Me-262 were ideal. Due to its enormous speed this plane could approach from its waiting position to within firing range of an enemy plane spotted by a searchlight beam within an incredibly short time.

In the matter of take-off and landing ability the He-219 proved outstanding because of its nose wheel. However, the abilities of the Me-110, Ju-88, and Do-217 in this field were adequate to permit all-weather operability.

1607 Night fighter defense action against British Mosquito aircraft remained an unsolved problem right up to the end of the war. These aircraft had a cruising speed of between 306 and 336 miles and a night fighter would have required a speed of approximately 420 miles in order to contend against it with any reasonable hope of success.

In a manner which remains hard to understand the Luftwaffe failed to take any steps to solve this problem. Field Marshal Milch, who was responsible for German air armaments, repeatedly pointed out the danger that the Royal Air Force might go over to mass commitments of Mosquito units; nevertheless, nothing was done on the German side to develop a night fighter with the required superior flight performances to cope with this threat.

The way in which the Luftwaffe treated this problem must be described as ill considered. Nobody could expect that a plane which, even during daylight, could not overtake a Mosquito plane sighted at a distance of 6 miles and travelling at top speed, would have any chances of success against the same target at night. Using a GM-1 booster attachment the Me-109, FW-190, Me-410, He-219, or Ju-88-R2 at their best
1608 could achieve the maximum speed of the Mosquito plane, which, when over enemy territory, always operated at only 10 percent under its maximum speed.

1608 For example, if a night fighter was committed against a Mosquito plane only six miles away it had to travel a distance of 60 miles at a speed 36 miles greater than that of its target, and thus at its own maximum speed for a period of ten minutes, in order to to establish visual contact with the target. This distance of 60 miles covered the operating range of between two and three Wuerzburg instruments and while thus passing from zone to zone target and night fighter had to be taken over successively by the various ground control positions. It was only on rare occasions that this turnover from one control position to the next functioned successfully, since the Mosquito was hard to detect and track with radar anyhow owing to its wooden construction.

For the above reasons all endeavors to counter British Mosquito aircraft operations by night fighter defenses using the existing types of night fighter aircraft were doomed to failure from the very outset.

It was only when the Me-262 was placed in service that the necessary conditions in the matter of aircraft performance and primarily in the matter of speed existed for successful anti-Mosquito aircraft operations. The outstanding results achieved by the Me-262 detachment at Berlin in spite of the

1608 hampering effects of the plane's short duration flight performance and of unfavorable weather conditions, showed that this type of fighter was the key to successful night fighter action against Mosquito type units.

Another aircraft type with adequate performances for effective night fighter action against Mosquito aircraft was the Do-335. Due to the late development of this type, however, practical experience on the subject came too late, again due exclusively to neglect on the part of the Luftwaffe.

The following lessons can be learned and experience deduced from the flight performances of German night fighter aircraft:

(1) The flight performances of German night fighter aircraft were at all times adequately superior to insure prospects of success in action against all conventional types of bomber aircraft in service on the enemy side.

In all respects the He-219 showed the best record of performances.

Success hinged primarily on a speed advantage of around 30 percent over the enemy bombers.

(2) Night fighter defense is always a problem of computing a point at which the night fighter will meet its target. The faster and higher the approach flight of the enemy, the greater margin of performance

1609 superiority will the defending night fighter require. Concurrently with a contracting outpost or forward warning area this margin of superiority must increase proportionately from 30 percent on, since the contracting warning area will require correspondingly faster reaction on the part of the night fighter. This also means, for example, that if the enemy speed is 600 miles at an altitude of 50 000 feet the defending night fighter's margin of superiority will probably have to be increased to 50 percent, if the enemy speed is still greater to around 100 percent, if it is to intercept the enemy in time, meaning before the enemy plane reaches its target.

1610 This requirement also marks the limit to which manned night fighter aircraft can be used at all in defense missions.

c. German Night Fighter Aircraft Equipment. In the matter of aircraft radio equipment and weapons German night fighter aircraft followed the pattern adopted for the daytime twin-engine fighter aircraft and therefore had all advantages accruing from this practically perfect solution.

It was found, however, that the night fighter, due to restricted vision at night, was hardly able to deliver fire at a long range and therefore did not require all of the weapons mounted in the turret. Two obliquely mounted

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1610 superheavy machine guns were completely adequate to set an enemy plane on fire with a short burst of weapons fire at a very close range.

Strange to say, the white coating of paint given German night fighter aircraft enabled them to approach from underneath to within a few yards of their target without being seen, so that they could shoot down their target from point blank range with the absolute certainty of not missing.

In the case of the German single-engine night fighter units the radio equipment carried was by no means adequate to meet the requirements of night operations over long distances and under all conditions of weather. It differed in
1611 no way from the standard radio equipment of daytime single-engine fighter units. For night operations equipment with self-orienting instruments and with instruments for landing by ultrashort-wave radio beacons was just as essential as it would have been for daytime all-weather operations, as described previously in the chapter on daytime fighter aircraft. On this point the Luftwaffe was guilty of seriously and irresponsibly neglecting the safety of its personnel and aircraft.

The weapons of the single-engine night fighter aircraft were definitely adequate to shoot down an enemy plane, since fire could only be delivered at very close range at night, and since their unprotected fuel tanks made the British

1611 bombers far more vulnerable to weapons fire than the American 4-engine bombers.

The following lessons can be learned and experience deduced from the equipment of German night fighter aircraft:

(1) The necessity for night fighters to be able to operate over large areas and under all conditions of weather presupposes radio equipment insuring secure navigation, all-weather take-off and landing ability, and air-ground communications.

(2) The fire power required will depend on the vulnerability of the enemy aircraft to weapons fire and the possibility to approach the enemy plane to within such close range that a short burst of fire will definitely be adequate to bring it down.

The greater the distance at which the night fighter must commence firing, the larger will be the number of weapons it requires; the less vulnerable the enemy planes are to weapons fire, the more effective will the ammunition and the density of the fire cone have to be.

1612 d. German Night Fighter Aircraft Production. From the moment when a start was made at establishing a night fighter arm, in the summer of 1940, the production of night fighter aircraft for the Luftwaffe suffered from the circumstance that the aircraft manufacturing program contained no provisions for a special type

1612 of aircraft designed specifically for allocation to the night fighter arm. It was due exclusively to the transfer of the bulk of all daytime twin-engine fighter units to the night fighter arm that it was possible at all to meet initial requirements in twin-engine aircraft and to maintain the strength of the existing night fighter units almost at authorized level up to 1943.

Due to the activation of new units, a shortage of 104 planes occurred for the first time on 27 December 1941, compared with an overall authorized aircraft strength of 406. On 30 September 1943 the arm was 404 planes short of its authorized strength of 978, and on 31 March 1944 it was 482 short of its overall authorized strength of 1047 planes. A tolerable balance was only restored on 30 September 1944 when the total actual strength was 1018 out of an authorized overall strength of 1071 aircraft.[798]

From the above figures it is clearly evident that up to the autumn of 1944 the output in night fighter aircraft was completely inadequate, and this in spite of the fact that the night fighter arm had the smallest loss ratio of all arms.

That it finally became possible to bring the night

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1612 fighter units up to a high level in actual strengths was due
exclusively to the allocation of a large share of Ju-88 planes
coming from current production and scheduled originally for
allocation to the bomber arm. This changed allocation was due
1613 to the withdrawal of a steadily increasing number of bomber
units from action and to the disbandment of some of them, and
was in no way a measure which could be credited to those respon-
sible for the armament program.

From the outset the ~~bomber~~ night fighter arm had to rely on allocations from output intended for the daytime twin-engine fighter arm (Me-110 and Me-410 aircraft), and on allocations from current output intended for the bomber arm (Ju-88 and Do-217 aircraft).

When the twin-engine fighter arm in 1943 again became an important component of home air defense the hitherto adequate allocations of Me-110 aircraft to the night fighter arm decreased, and as long as the bomber arm remained of current importance it remained impossible to release adequate numbers of Ju-88 and Do-217 aircraft for allocation to the night fighter arm.

From the above it is obvious how important it would have been to place the night fighter arm on its own feet at an early stage by allocating to it the output in He-219 and Do-335 aircraft, and by insuring that this output would be adequate.

1613 That the He-219 was not manufactured in adequate numbers, and that this was not due to reasonable causes, together with the fact that no better solution of the problem was offered, must be described as a failure on the part of those responsible for Luftwaffe armament planning and as a failure which could have been averted. All later endeavors to promote the production of He-219 and Do-335 aircraft were made long after the military situation in general and the air situation in particular had so far deteriorated that there was no longer any basis for the assumption that these endeavors could succeed.

When the Fighter Armament Program finally resulted in adequate strengths being available in the twin-engine night fighter forces in the autumn of 1944, the hitherto inadequate strength of the night fighter arm had already produced the inescapable and irrevocable results. The difficult operational conditions created by the British tactics, the impossibility to obtain clear interpretations of the air situation, the interferences to which the SN-2 radar instruments were now subject, combined with the general fuel shortages produced conditions in which the numerical strength of the night fighter arm could no longer bring about the favorable results it could have done one or two years sooner.

The following lessons can be learned and experience deduced from German night fighter production activities:

1614 (1) To insure optimum execution of its mission, each specialized air arm must have available a type of aircraft developed specifically for the execution of those missions.

The tendency towards a development of multi-purpose aircraft might have advantages in the matter of large-scale serial production, but these apparent advantages will always prove fallacious. In the long run only the superior quality obtainable in a type of aircraft developed specifically for its specific purpose can insure economical use of forces. Any compromise in the form of a multi-purpose type of aircraft necessarily must result in excessive losses due to inferior performances.

(2) In point of the performance requirements for a night fighter aircraft, it combines the feautures of a bomber with those of a fighter plane. It has the features of a bomber in its requirement for large area operability and all-weather operability, and the features of a fighter because of its necessity for flight performances superior to those of the best types of bombers.

To use as a night fighter a type of aircraft developed primarily for use as a bomber or as a fighter is always a poor compromise. A properly balanced combination

1615 of the required features of the two types can only be achieved in a plane designed and constructed specifically for that purpose.

(3) Production plans providing for too large an output can never do any harm. Inadequate provisions can produce irremediable results which might decide the outcome of a war.

CHAPTER 4

ANTIAIRCRAFT ARTILLERY

I. ORGANIZATION AND STRENGTH.

The official measure placing the antiaircraft artillery under the Luftwaffe and integrating it with the Luftwaffe forces on 16 March 1935 indubitably constituted a decision of the first magnitude in its effect on the development of this arm.

The advantage for the antiaircraft artillery arm accrued not only from the fact that the Commander in Chief of the Luftwaffe, Goering, at the same time was a person who exercised an overpowering influence in politics and economy, but also from the fact that this measure gave the Luftwaffe as a whole a stature hardly below that of the entire army.

In combination these two factors made the resources of the Nation in personnel and armaments available to the antiaircraft artillery arm in a measure far exceeding that which would have been the case if it had remained a component of the Army forces.

Events in the war also proved how sound this measure had been from the viewpoint of indivisible interplay of combat tactics, techniques, and technological developments between

1616 air power and antiaircraft artillery forces. Only a command headquarters responsible for the conduct of air operations and for the commitment of air units can be in a position to appraise properly the current missions of an antiaircraft artillery force and the nature of its future urgent missions.

A tangible result of the interplay referred to above became evident in the development of the antiaircraft artillery arm in 1937 as action commensurate with the concepts of the Luftwaffe concerning the use of aggressive air forces, in that the evolution of the theory of dive-bomber attack produced a program for the activation of medium and light antiaircraft artillery units. Although Germany's later opponents did not at the time adopt the theory of dive-bombing attack, and although bombing while in horizontal flight remained the predominant feature in aggressive air warfare throughtout the war, the large number of medium and light antiaircraft units thus activated produced excellent results in defense against fighter-bomber and low-altitude attacks by enemy forces during the war.

The final decision at the end of 1938 to organize the antiiarcraft regiments each in 4 heavy plus 2 light gun battalions, 1 searchlight battalion, and independently operating battalions of 1 medium and 2 light gun batteries made the

1617 antiaircraft artillery regiment a tactical unit of extraordinary strength and effectiveness for daytime and night air defense.

The fact that all units were fully motorized facilitated their quick concentration to form points of main effort.

Under these circumstances the assignment of the antiaircraft artillery forces under the local air district command headquarters, as the headquarters responsible for air defense within their circumscribed command areas, represented the most logical and practical solution for home air defense purposes.

Plans provided for a separation of command responsibilities in the event of war in which the antiaircraft artillery forces committed in the home air defense mission were divided from those committed in air defense missions at the front, in the Army zones of operations. These latter were placed under the appropriate Tactical Air Support Commands attached to the various army headquarters to control the forces of the Luftwaffe assigned to support the operations of the Army.

Since the Luftwaffe alone, in the event of war, was in a position to evaluate the overall air situation in all theaters of war, and since enemy air activities in all cases would be related to the German strategic objective aimed at in own air operations, it was logical and appropriate that

1618 the Luftwaffe throughout the entire war retained the right to decide on the distribution and disposition of its antiaircraft artillery forces.

The only case in which an exception was made was that of the Navy, which had its own antiaircraft artillery forces on land. There can be no doubt that this arrangement was suited to the purpose, since so many naval factors were involved in the problems of defense for coastal areas and port installations, and in view of the importance of these factors, that the Navy alone was in a position to protect its own interests in this field and to insure execution of the defense mission. This arrangement undoubtedly was related to the circumstance that no final decision had been reached by the outbreak of the war on the question of placing naval air units under control by the Navy for the conduct of air warfare at sea.

The results achieved by the Luftwaffe in building up the antiaircraft artillery arm in the 1935-39 period must be considered as outstanding. Starting out with only 9 so called truck battalions (Fahrabteilungen) taken over from the Army on 1 April 1935, the antiaircraft artillery arm by August 1939 had grown to a strength of 26 antiaircraft artillery regiments comprising 59 composite battalions, 18 independently operating light gun battalions, and 18 searchlight battalions, in addition to 14 heavy cadre batteries.

Appropriately distributed among the ten air district command headquarters plus Headquarters, Senior Commander, Fortifications Antiaircraft Artillery III (Festungsflakartillerie III), which was the headquarters controlling Air Defense Zone West, these forces provided adequate protection, so far as ground defenses were concerned, for all targets of air attack within Germany. This whole system could be regarded as a particularly reliable support in view of the fact that the firing achievements of antiaircraft weapons when measured by the speed and operating altitudes of the bomber aircraft then in existence were so excellent that even a battery operating under a centralized fire control could be considered as a tactical weapon with an immense repelling power.

For these reasons it was a fully justifiable measure during the Polish campaign, and even more so during the 1940 campaign in the westto withdraw strong antiaircraft artillery forces from the Home Defense Zone for commitment in the Army zones of operations. This was particularly so in view of the fact that mobilization plans, which were fully carried out, provided for a tripling of the number of antiaircraft artillery units in existence.

In the Polish campaign the antiaircraft artillery forces committed in the Army zones of operations were assigned under the various Tactical Air Support Commands attached to the

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1619 individual Army headquarters in the field. For the 1940 campaign in the west, in contrast, the bulk of the antiaircraft artillery forces supporting Army operations were organized under the command of Flak corps headquarters. These remained under direct command by the Luftwaffe, but in tactical matters were required to cooperate closely with the Army. The soundness of this solution was vindicated so evidently by the success achieved by these antiaircraft artillery corps that it was retained in principle in all theaters of mobile operations

1620 throughout the war. In the eastern and southern theaters the firmly controlled antiaircraft artillery units provided a practically invincible backbone of defense on the ground, and often proved the deciding factor in battle. They could have served the same purpose in the western theater in 1944, after the beginning of the invasion by the Western Allies, if much larger forces had been committed under the usual firm command control.

Development of the antiaircraft artillery arm during the war shows a progressively growing strength which reveals the existence of a well planned program and a well organized execution of that program. The establishment and execution of such a program would hardly have been possible but for the extraordinary regard which Hitler, as Commander in Chief of the Wehrmacht, had for the arm. This high regard is evidenced

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1620 by his statement on 27 January 1941 concerning the "....necessity for an immense antiaircraft artillery arm with very large supplies of ammunition," which firmly established the direction for future development of the arm, and by his order issued as late as on 4 November 1944 calling for"....an exceptionally strong reinforcement of antiaircraft artillery armament," which served as an express confirmation of his first statement.

In spite of the gigantic efforts expended, and in spite of the enormous results achieved, in the build up of the antiaircraft artillery arm, which during the war reached a strength four time that at the end of 1939,--after the reinforcements due to the unit activations carried out after mobilization, the requirements for antiaircraft artillery protection caused by the expanding theaters of operations and by the need for the allocation of stronger units to protect specific targets grew faster than the build up could proceed.

This fact made it necessary to adopt improvized solutions, such as the activation of barrage fire batteries armed with captured guns in 1940-41, the commitment of training units in tactical missions, and the activation of auxiliary home antiaircraft batteries (Heimatflakbatterien) and"Alarm" antiaircraft batteries, all of which served to create the dangerous illusion of existing defenses, which in actual fact were of very small practical value.

1621 The large number of antiaircraft artillery units activated during the war naturally created the need for a commensurate command organization. In developing this command organization the Luftwaffe based its measures on the sound principle that in every area where a number of units were committed to defend a single target or a number of targets located within a confined space a superior headquarters was necessary to insure a uniform direction of operations and the appropriate power concentrations.

Taking into account the fact that at the end of 1942 only the 6 antiaircraft artillery division headquarters formed in August 1941 from the former air defense command staffs were available to direct the operations of forces including 632 heavy batteries alone within the Home Air Defense Zone, the activation of 2 division headquarters (21st and 22d) in Darmstadt and Dortmund and of 4 brigade headquarters (4th, 16th, 20th, and 21st) in Munich, Vienna, Stuttgart, and Nuremburg, in the spring of 1942 must be considered a very belated measure.

If criticism is levelled at the Luftwaffe for the large number of command headquarters it had, this by no means applies to the antiaircraft artillery arm, even as it existed in the last years of warfare.

An entirely different question is that of whether it was a sound wartime measure in theaters of static warfare, such

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1621 as the Home Air Defense Zone, and the western and northern theaters, to place the division and brigade headquarters under the air district commands.

The measure must be considered unsound for the following reasons:

(1) In addition to their tactical missions, of air defense operatoons, the air district commands had the entir tire responsibility for the Luftwaffe ground service and supply services. This necessitated a very large headquarters staff, in which all staff divisions needed the attention of the commanding general and his chief of staff.

This meant that the command echelon of the staff had too many other duties which detracted the attention of its members from tactical problems, and was not able to divide its time properly for attention to numerous matters of co-equal importance, as would in many cases have been necessary This necessarily had a harmful influence on the conduct of combat operations.

(2) Almots all of the officers commanding the various air district commands came from the antiaircraft artillery arm. This resulted inescapably in an emphasized concentration in the air district command headquarters on matters of the antiaircraft artillery arm and hampered smooth co-operation with the fighter defense forces.

1622 It would have been much wiser to consolidate the forces of active air defense, namely, the fighter and antiaircraft artillery forces, within specific air defense areas already at an intermediate level of command. For example, air defense corps headquarters could have been established to control fighter and antiaircraft artillery divisions, leaving the air district commands, as regional headquarters of the territorial organization, responsibility for the Luftwaffe ground service organization, supply activities, and the passive air defense system.

1622 Another question discussed among circles responsible for the air armament program was that of the advisability of continuing to expend so much man power and material to develop and maintain agigantic antiaircraft artillery defense organization. In view of the development of the tactical and technological means of attack on the enemy side and the resultant progressively growing requirements for renewed reinforcement of the antiaircraft artillery forces and the commensurate expansion of the whole organization, these circles doubted whether the huge expenditures were justifiable at a time when the armament resources in general were under a severe strain.

This problem became one of acute importance at the time when the fire power of the antiaircraft artillery battery, as the tactical unit of fire, was no longer adequate to inflict noticeably heavy losses on the enemy, so that it became necessary to adopt the tactics of mass fire delivered by super-batteries formed through the consolidation of a number of batteries under a central uniform fire control. This implied transition from the principle of fire for destruction to one of fire to achieve repelling effects, coupled with the hope of achieving chance hits.

In examining this problem reasoning must be based on the principle that only planes actually brought down over friendly territory can be counted as actual enemy losses. The loss of an entire crew is always a more serious matter than the loss of an airplane. This is so because personnel losses will always affect the morale, and because personnel are harder to replace than materiel. Damage done to aircraft by fragments might put the aircraft out of action for some time, but it is not a fatal loss and cannot have a serious influence on the strategic plans of the enemy.

1624 For these reasons all antiaircraft weapons no longer adequately effective, because of their outdated firing performances, to actually shoot down enemy aircraft were nothing but a drag on the entire arm and served to give the higher commands a false impression of the actual defensive strength available.

This situation existed in the German antiaircraft artillery forces practically throughout the war from 1941 on. A

1624 large percentage of the units, including the auxiliary home and the "Alarm" batteries as well as all units which still had pre-war gun types, required large numbers of personnel and large quantities of materiel for their maintenance without achieving commensurate results, in the form of enemy aircraft shot down, worth their expendituture in ammunition.

It would have been a far sounder policy to maintain only as many antiaircraft artillery units as it was possible to keep equipped with modern guns and modern fire control instruments. The effective results achieved would not have been smaller than they were if measures had been introduced in 1943 to commit only those heavy batteries in home air defense which had 88-mm type 41, 105-mm, or 128-mm guns, or which could be allocated guns of these types within the foreseeable future. The less modern guns could have been used to far better purpose in the eastern theater. As more modern guns and firing control instruments became available from current output, batteries could then have been recalled from the eastern theater

1625 for reequipment and commitment in home air defense.

How faulty the organizational structure was is proved by the fact even at the end of the war a large percentage of the heavy batteries employed in air defense against the Western Allies still had Type 18 and 38 88-mm guns and were serviced by auxiliary personnel. The resources thus wasted could have

1625 could have been used far more profitably for other purposes, for example, for the production of fighter aircraft.

The following lessons can be learned and experience drawn from the organization and strength of the antiaircraft artillery forces employed in the German air defense system:

(1) As a weapon of air defense, the antiaircraft artillery must be considered as an organic part of the air forces. This is the only way to insure that developments in the field of means of air attack will have a direct influence on the development of means of air defense. It is also the only way to insure a centralized direction of all forces for concentrated action at the currently critical points to serve the best interests in the overall condutt of a war.

(2) To secure smooth and proper cooperation the antiaircraft artillery forces committed in air defense zones within areas of static warfare must be consolidated at the intermediate levels of command with forces of other arms participating actively in the air defense mission.

(3) The command headquarters responsible for the conduct of operations must be relieved of all responsibility for other matters, such as the ground service organization, and supply and training activities.

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1625 (4) The existence of antiaircraft artillery forces as a component of air defense can only be considered justifiable as long as these forces are able to shoot down enemy aircraft at a tolerable cost in ammunition expenditures.

(5) The continuing process of improvement in the field of means of air attack creates the necessity for a high degree of specialization in the personnel and equipment on the defending side.

The strength of an antiaircraft artillery arm as a component of air defense therefore can only be measured by its degree of specialization and not be the number of weapons it possesses.

XII. RESULTS ACHIEVED BY THE GERMAN ANTIAIRCRAFT ARTILLERY DEFENSES.

At the beginning of the war in 1939 the German antiaircraft artillery forces had the advantage of actual experience gained in air defense missions and combat against ground targets in the Spanish Civil War. In that war the resounding successes achieved in air defense missions had fully vindicated the excellent quality of the German guns and firing equipment.

The superiority of the German antiaircraft artillery forces was due to the high muzzle velocity of their guns, the rapid rate of fire of their guns, and and the excellency

1626 of their aiming equipment. However, this superiority was conditional, since it depended completely on the nature of the targets taken under fire.

The antiaircraft fire hypotheosis was based on a precise determination of distance, speed, altitude and direction of travel of the target in order to fire a projectile at that point which the target would reach if it continued on the same course and at the same altitude and speed during the time which the antiaircraft missile would take to reach that point.

1627 The slower the target and the lower its altitude, on the one hand, and the higher the muzzle velocity and rate of fire of the antiaircraft artillery gun, on the other hand, the smaller was the allowance which had to be made for lead and for changed action of the target and the greater was the number of missiles which the gun could fire against the target while it was within effective range.

In the early phases of the war enemy bombers operated at speeds between 150 and 180 miles and altitudes around 13 000 feet. Against such targets the heavy antiaircraft guns had decidedly good chances for action with a high degree of probability of achieving total destruction of the target.

The same advantages were evident in the medium, 37-mm, guns for action against targets at altitudes up to 8 200 feet

1627 and in the light weapons for action against targets at altitudes up to 3 300 feet.

From what has been said above it is obvious that any marked increase in the speeds and operating altitudes of aircraft would influence the lead allowance factor to such a degree that the chances of achieving hits with antiaircraft fire would gradually decrease. Practical experience showed that if the shell ignition had to be set at longer than 25 seconds the prospects of success with antiaircraft fire were practically nil.

Another factor influencing the effectiveness of antiaircraft fire was the degree of vulnerability of the target to weapons fire. The effectiveness of antiaircraft shells relied not only on the achievement of a direct hit with shells with impact ignition, but also on fragmentation effects when shells with time fuzes exploded in the air near the target.

1628 For example, the effective fragmentation radius of an exploding 88-mm fragmentation shell was 33 feet, and within this radius a fragment of the shell could destroy a vulnerable target. If the target was less vulnerable to weapons fire, this decreased the effective fragmentation radius of the shell; this in turn created the necessity for more accurately aimed antiaircraft fire if it was to result in destruction of the plane aimed at.

1628 The results obtained with antiaircraft fire were thus determined by four factors:

(1) The availability of accurate target distance, speed, and altitude data.

(2) The fuze setting, which equalled the lead allowance factor.

(3) The effective fragmentation radius of the shell.

(4) The rate of fire of the antiaircraft guns.

It is in the light of these four factors that the results achieved by the German antiaircraft artillery defenses during the war in the various theaters and under the varying circumstances existing on the enemy side must be examined.

If the enemy succeeded in preventing the precise functioning of the electrical target data procuring instruments, this would discount even the very best ballistical performances of a gun; if the operating speeds and altitudes of the enemy aircraft were too great, this made the lead allowance factor too great for effective fire; and if the enemy planes were at too low an altitude this made the effective radius of the guns very small and greatly reduced the number of rounds which the gun could fire at its target.

The noticeable results achieved by the German antiaircraft artillery within the operational zone of the Army--in 1940 during the western campaign and in the southern theater, 1629 and in the eastern theater throughout the war--serve to show that tactical conditions for antiaircraft artillery operations had remained favorable. The enemy aircraft did not fly too high or too fast, carried out the most of their attacks during daylight and during conditions of good visibility and, particularly in the eastern theater, made large use of ground-attack air units which provided ample opportunity for the German meium and light caliber weapons to exploit the advantages of their high muzzle velocity and high rate of fire.

In the case of night attacks by units of the Royal Air Force, the tactical conditions for the defending antiaircraft guns were considerably less favorable from the very outset. Target data procurement was impaired in all cases because it was possible to take action against only one target at a time, the target which was held by searchlight beams so that visual data could be computed with the instruments. The possibilities here were further reduced by the tactics of the Royal Air Force units, which operated at low altitudes and by individual planes both during the approach and home routes. This meant that the targets left the tracking zone too fast, thereby reducing the time during which the target could be tracked for the computation of the necessary firing data.

In addition, weather conditions did much to complicate searchlight operations while allowing adequate ground

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1629 visibility for the enemy bombers to do their bombing.

The serious degree to which searchlight operations depended on weather conditions, and the curtailments this imposed on antiaircraft fire at night, led to an early realization that it was not possible to build up a really effective system of 1630 antiaircraft artillery defense on this basis against attack at night. For this reason the antiaircraft artillery immediately showed a very keen interest in the developments which commenced in the autumn of 1939 when the first radar type instruments produced indicated the advent of new possibilities for all-weather target data procurement.

The equipment of all heavy antiaircraft artillery batteries with Wuerzburg type radar instruments for the procurement of aircraft lateral, distance, and altitude data became a matter of acute importance when the Royal Air Force, as early as on the night of 16-17 December 1940, started its program of large-scale concentrated attacks against German cities with an attack against Mannheim in which 100 tons of bombs were delivered on the target area. The same circumstances at the same time created the urgent necessity for allocation of such equipment to the night fighter arm, the Navy, and the aircraft reporting services, and this at a time when the new electrical target data procurement instruments to a large extent were still in the experimental stages. One complicating factor here was

1630 the+the first, Type Wuerzburg-A, radar instruments delivered did not produce data precise enough for antiaircraft artillery action against aircraft.

The fact that the after-action report submitted by Air Command Center on 1 August 1941 states "the Type Wuerzburg-A instruments (AAA) do not furnish useful firing data for destructive fire and must be replaced by 1 October 1941 through allocation of 236 Type Wuerzburg-C and D instruments" shows clearly that the value of the "target data factor" was still limited at this juncture so far as the antiaircraft artillery was concerned. However, the antiaircraft artillery remained subject to this handicap of inadequate equipment equipment with more effective radar instruments because the night fight-
1631 er arm also had to depend exclusively on these instruments in its Himmelbett waiting position tactics of air defense, and the inadequate output made it impossible to allocate to each of these two users the numbers of instruments required at the appropriate speed.

There was hardly any opportunity to bring about a change in this situation. The progress made in the Russian campaign, in submarine warfare, and in the campaign in Africa in 1941 resulted in a generally optimistic mentality in the highest levels of command and in a tendency to place main emphasis on reinforcement of the aggressive branches of the military

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1631 forces. It was therefore not possible to obtain the highest priorities for the development and production, within the over-all armament program, of what had to be considered primarily as means of defense, and these high priorities would have been necessary in 1941 if the means were to be made available in adequate quantities two years later.

When equipment of the antiaircraft artillery forces with electrical firing data procuring instruments had finally made some progress in 1943, the Royal Air Force with its tinfoil methods succeeded in bringing about the practically total elimination of the whole electrical target data procurement system of the antiaircraft artillery arm. The serious failure of the Luftwaffe in the field of precautionary measures has been dealt with previously in this study, in Chapter 3, Section II: "Night Fighter Defenses." British tinfoil operations had a far more serious impact on the German antiaircraft artillery than on the night fighter arm, since the latter was still able to rely on air-carried search instruments and on new methods holding out prospects of success. The antiaircraft artillery arm, in contrast, found itself in the same position it had been in in 1939-40 with the added handicap that the stage of perfection hitherto achieved on the enemy side in the matter of blind bombing almost completely eliminated the possibilities of searchlight support at night for the

1632 visual procurement of target data.

For the whole rest of the war the antiaircraft artillery found itself unable to recover completely from the serious blow it had received, in the field of night air defense, from the introduction of tinfoil methods of radar interference. Numerous countermeasures were tried out, some of which, as in the case of the Type Taunus instrument, served to reduce interferences to some extent, but no completely satisfactory solution was found up to the end of the war which could have served to restore the reliability of the "target data" factor.

What further complicated matters was the changeover of t the Royal Air Force to 4-engine bombers which were faster, less vulnerable to weapons fire, and operated at higher altitudes. This reduced the value of the "fuze setting or time lead allowance," and of the "effective shell fragmentation radius" factors, thereby still further decreasing the opportunities of the antiaircraft artillery for night defense action.

The necessity for defense action against Mosquito type bombers operating at speeds of around 336 miles and at altitudes between 30 000 and 33 000 feet produced for the antiaircraft artillery defenses a problem hardly possible of solution.

That antiaircraft artillery defense in the Home Air Defense System proved unsatisfactory was thus not due to the weapons as such but to the inability to create conditions commensurate

1632 with the potential effectiveness of the weapons used.

In dealing with this subject it is necessary to establish that the Antiaircraft Artillery Inspectorate at an early stage recognized possible developments in the realtions between attack and defense forces and with extraordinary vision indicated the way in which it would be possible to counter de-

1633 velopments in the field of means of attack with prospects of success.

The study submitted by the Chief of Antiaircraft Artillery Forces on 6 February 1942 refers clearly to the four factors on which success in antiaircraft artillery defense operations hinges, namely,

(1) The all-weather procurement of precise target data is possible only with electrical target data procuring equipment. However, it is to be assumed with all probability that commensurate countermeasures by the enemy will reduce the effectiveness of such equipment seriously. Therefore it is essential to develop interference proof radar instruments for the antiaircraft artillery arm.

(2) In view of the increasing speed and operating altitudes of aircraft, antiaircraft fire with shells having a time-in-trajectory of more than 25 second no longer holds out any prospects of success because too large a

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1633 lead has to be allowed.

Therefore, departure from the antiaircraft fire hypothesis is recommended through development of antiaircraft rocket missiles, designed either for remote control or for self-steering.

(3) The reduced vulnerability of enemy aircraft to weapons fire calls for increasingly effective antiaircraft missiles to be achieved through larger calibers and larger explosive charges.

(4) In addition to the above it is necessary to increase the rate of fire ofmedium and light antiaircraft guns, since it requires a number of direct hits with shells of these calibers to shoot down a modern airplane.

The characteristic features of this study on the antiaircraft artillery problem are the clarity with which the existing situation is outlined and the foresight with which
1634 the inferences to be drawn for the future development of weapons are indicated.

The study draws no fanciful picture of utopian possibilities. Instead it states actually realizable requirements, This fact, however, was only proved by later events.

Although the study on September 1942 received the official approval of the Commander in Chief of the Luftwaffe

1634 and was issued as a directive for the future development of weapons, there is no evidence that any initiative was brought into play to bring about revolutionizing changes in antiaircraft armaments. It is hard to understand that in the Special Supplies and Procurement Services conference of 23 August 1943 the matter of antiaircraft artillery with greater effectiveness formed a topic for discussion as a problem for which no concrete solutions could be indicated.

It was only in the Special Supplies and Procurement Services conference on 27 January 1944 that it was stated with general clarity that "....the development of antiaircraft rocket missiles is the decisive problem in the entire field of ground defense." At this time, however, it was already clearly evident that there would be no possibility before mid-1944 of even recognizing what direction developments would take.

It must therefore be stated as an established fact that the Luftwaffe High Command did not take seriously enough the problems brought out in the Study of February 1942 or the possibilities stated there for their solution, and that the command took no steps to bring about a change in the whole concept of antiaircraft fire. The outcome was that the antiaircraft artillery could only hope for success through the mass commitment of guns and ammunition.

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1635 Here again, the situation was complicated by the increasingly acute shortages in man power and materials in the armament industries, which in turn made improvised measures necessary, and these resulted in an overall progressive decline in performance standards.

Matters were no different with the antiaircraft artillery forces employed in daytime air defense. With the advent of the US 4-engine bomber forces, these antiaircraft artillery forces found themselves precisely in the situation which the study of February 1942 had predicted: Owing to the increased operating speeds and altitudes of the new enemy forces the time in trajectory flight of antiaircraft shells was too great for antiaircraft artillery fire to produce adequate results.

The extreme effective range of the older types of antiaircraft guns in service was about 26 000 feet, and the German armament industry was unable to remedy the new situation by an increased and accelerated production of the 88-mm (Type 41) and larger caliber guns to replace the obsolete types. In the autumn of 1943 matters became even more difficult when the US bomber forces on an increasing scale went over to blind bombing tactics while at the same time hampering the operations of the German electrical equipment through the use of tinfoil and jamming instruments on their aircraft.

1635 All of these circumstances contributed to produce conditions in which antiaircraft artillery defense was just about as ineffective during daylight as at night.

The Luftwaffe High Command should have realized as early as in 1943 that in action against enemy aircraft operating at altitudes above 23 000 feet and at speeds above 210 miles the antiaircraft artillery had reached the extreme limits of effective antiaircraft fire with weapons of the conventional types. Increased muzzle-velocities, larger calibers, increasingly effective shells, and improved radar instruments with better protection against interference might have done something to ameliorate the situation but could not be considered as a satisfactory long-range solution of the problem. The effectiveness of enemy attacks by Mosquito units alone was a warning which should have been more than clear enough. Finally, it was known that with their Superfortress aircraft the Americans could carry out attacks while operating at altitudes above 33 000 feet, and this was the extreme effective range of the German 128-mm antiaircraft guns.

In the light of these circumstances it can only be said that in the case of the daytime antiaircraft artillery forces the inadequate results achieved in action against the western opponents was also due to the fact that they were required

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1636 to execute their defense mission with inappropriate means. The Luftwaffe made the same mistake here which it had made in the case of the fighter arm. It endeavored to find a solution to the problem through increased quantities instead of improved quality and delayed too long in its decision to abandon the antiaircraft fire hypothesis principle in order to place full emphasis on the development of antiaircraft rocket missiles, which would have opened up a wide range of possibilities for action from aircraft or from the ground.

The following lessons can be learned and conclusions drawn from the performances achieved by the German antiaircraft artillery:

1637 (1) By the laws of ballistics the effectiveness of antiaircraft guns of the conventional types reaches the extreme limit when the time required for the antiaircraft missile to reach its target, and thereby the lead allowance factor, becomes too great. This factor is determined by the altitude and speed at which target aircraft operate.

(2) Beyond the conventional antiaircraft gun's range of effectiveness, the only possibility to shoot down aircraft is by the use of missiles propelled by a power unit or charge giving them a constant speed superior to that of the target and guided by a homing device which will insure full hits without the necessity for a lead allowance.

1637 (3) As in the case of other weapons, it is also essential in the case of antiaircraft artillery weapons to give the principle of quality priority over that of quantity, since war will impose potential limitations on quantities in all fields.

(4) If the antiaircraft artillery is to keep pace with developments on the attacker side, a far sighted program for development must exist from the very outset. This is so because the defense will always have to respond to methods introduced by the attacker, and because all new developments require a long time for preparation in the present age of high precision and complicated technology. This means that supersonic speeds and stratospheric altitudes should have been taken into account in planning even at a time when current achievements were still far below such levels.

1638 (5) As in the case of the fighter arm, the antiaircraft artillery as a weapon of defense must at all times achieve a higher level of performances than the weapons of attack in order to maintain an advantage of superiority.

Thus, if the attacking aircraft are rocket propelled, this will reduce the rocket driven antiaircraft missile to the level of an inappropriate means of defense. The next level for improved rocket performance would then be

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1638 atom power. At the same time scientists must set their minds to discover a means for the use of sound waves as a weapon for defense against any form of matter.

III. INTEGRATED FIGHTER-ANTIAIRCRAFT ARTILLERY ACTION.

The regulations in existence before the war governing cooperation between the antiaircraft artillery and defense fighter forces, as formulated in Air Field Manual LDv 16, were founded on a purely hypothetical basis. Since both the daytime and night fighter defense system was based on the use of small and highly maneuverable single-seater aircraft, the risk of hits by friendly antiaircraft fire did not appear too great. Where the terms of Air Field Manual LDv 16 required a clearly defined division between the night fighter and the antiaircraft artillery fire zones, this was due primarily to the necessity to insure immediate and unrestricted antiaircraft fire action against any aircraft entering the zone of antiaircraft fire, and to avoid the possibility that

1639 the sounds from the engines of friendly fighters might interfere with the functioning of the sound locators used to direct operations of the searchlights. The excellent performances of antiaircraft guns against the aircraft then in existence made it possible to rely exclusively on the antiaircraft artillery for defense within the circumscribed antiaircraft fire zone and employ night fighters

1639 along the enemy routes of approach and return flight.

The matter of cooperation between the antiaircraft artillery and night fighter forces in the air defense mission only became a problem of acute importance when the enemy had developed tactics of night attack which practically restricted the possibilities for successful counteraction by night fighters to the zone of antiaircraft fire. This situation arose

(1) With the establishment of the single-engine night fighter forces in July 1943. Having no air-carried radar type search equipment, these units had to depend on illumination of their target by searchlight or by the glow of fires.

(2) With the elimination of possibilities for the "Himmelbett" waiting position tactics of night fighter defense through tinfoil interference with the Wuerzburg radar instruments. This also restricted the twin-engine fighter forces to direct target defense action, with the exception of those units which already had aircarried Lichtenstein SN-2 equipment.

(3) With the introduction of night fighter pursuit operations in August 1943. Using their SN-2 search equipment, German twin-engine night fighters now flew with the enemy force into the antiaircraft fire zone and were thus exposed equally with the enemy aircraft to the effects

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1639 of defense fire from the ground.

(4) With the restriction of possibilities for successful antiaircraft fire from July 1943 on due to the enemy use of tinfoil to eliminate the German radar instruments. It was now of increased importance to insure unrestricted entry by defending night fighter forces into the antiaircraft fire zone, where they found exceptionally favorable chances to shoot down enemy aircraft.

It was therefore of the urmost importance to find an arrangement which would make it possible for defending night fighters to operate over the antiaircraft fire zone without exposing themselves to the hazards of friendly antiaircraft fire.

In its antiaircraft fire regulations issued on 21 August 1943, Air Command Center sought a solution to this problem by a ~~vertical~~ horizontal division of the zones of antiaircraft artillery and fighter action. Taking the average altitude of attacking enemy air units as a base line, night fighters were assigned responsibility above and antiaircraft artillery forces below that line.

Theoretically, this solution served its purpose to full perfection. In practice, however, it remained unsatisfactory since its application depended on too many uncertain factors.

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1640 The attachment of "antiaircraft fire control officers" to fighter command posts in January 1944 was an effort to secure better coordination between the antiaircraft artillery and fighter forces in action over the target area. The all-important weakness in this system was that the control officers could only submit recommendations and could not issue direct orders. This meant that responsibility for the decision when and what form of antiaircraft fire should be imposed remained with the local antiaircraft artillery commander, who could only make this decision when the attack actually commenced and thus too late.

The night fighters almost always ~~had~~ just cause for complaint about interference with their operations by heavy antiaircraft fire over the target area, while the locally responsible artillery commander maintained that too few night fighters had been over the target area in time to justify any drastic restriction of antiaircraft fire. It was impossible at any time to clarify the situation satisfactorily, since no possibility existed to keep complete track of all movements of the night fighter forces.

The new regulations for antiaircraft fire restictions dated 28 February 1944 authorized the release of fire to all altitudes over the target area if less than twenty night fighters were present, and established that fire was to be

1641 restricted to a ceiling of 21 000 feet only if large numbers of night fighter aircraft were over the target area. In practice this gave the antiaircraft artillery absolute priority, since the Royal Air Force units as a rule operated at altitudes under 21 000 feet.

The priority of antiaircraft artillery fire in the air above target areas was even more clearly established by the Commander in Chief of the Luftwaffe in an order dated 21 June 1944, and prohibiting any restriction of antiaircraft fire over specific targets protected by strong antiaircraft artillery forces, such as fuel producing and processing works, Rhine River bridges, valley dams, and airfields.

This arrangement for the coordination of operations by the antiaircraft artillery and night fighter forces, a subject which presented no problems during daylight, remained in force up to the end of the war. In practice the problem was never completely solved, since coordinated action by the two arms
1642 within the antiaircraft fire zone was never achieved without mutual interference.

The question arises here whether there was any possibility at all of finding a better solution. Efforts to do so should have been made when practice, in the form of night fighter losses indisputably due to German antiaircrfat fire, proved

1642 how unsound the theoretically sound arrangement actually was.

In weighing the chances for success of the antiaircraft artillery against those of the night fighter arm in night direct target defense, it becomes obvious that those of the night fighter arm were far greater after the British started using tinfoil. Measures hampering their action therefore had a far more serious effect on the success of defense efforts than any measures could have had which might have imposed excessive restrictions on antiaircraft fire.

In night fighter operations the chances of success were governed by the following factors:

(1) Favorable weather conditions which imposed no restrictions on night fighter aircraft in their take off and landing, and with conditions of good visibility at the approach and return route altitudes of the enemy forces, which experience showed were usually between 16 500 and 23 500 feet up.

(2) An early enough take off by the night fighter units to enable adequate numbers of them to reach all possible targets of enemy attack simultaneously with the attacking enemy forces.

(3) Reliable and clear air intelligence information making it possible at an early stage to direct the reconnaissance planes and night fighter aircraft equipped

1642 with Sn-2 radar search instruments into the enemy force. The enemy planes shot down by these units marked the ~~xxxxx~~ course taken by the enemy force so plainly that it was impossible for the bulk of the night fighters to miss it.

From the above it is evident that the night fighter commands were able to judge at an early stage whether an adequate number of night fighter aircraft could be sent into action at all and whether it was probable that they would reach the target simultaneously with the attacking enemy force.

If adequate numbers could be committed and if they could reach the target in time, orders restricting antiaircraft fire should have been issued, concurrently with the take off of the night fighter units, to the antiaircraft artillery and to the night fighter units participating in the current operations. This was the only possible way to insure that such orders would reach all participants in time.

If unexpected circumstances developed during the operation and made it appear unlikely that the bulk of the night fighter units committed would reach the target in time it would still have been possible to rescind the orders restricting antiaircraft fire within the zone of the target under enemy attack. Even if such orders failed to reach all antiaircraft batteries involved the consequences would not have been as serious, because of the very limited chances of

1643 success with antiaircraft fire, as those caused when the operations of night fighter units were prevented by unrestricted antiaircraft fire over the target area.

The following lessons can be learned and experience deduced from German efforts to secure coordinated action by antiaircraft artillery and fighter forces:

(1) In defense operations it is essential to achieve optimum coordination of action by all participating arms against the enemy.

(2) If the chances for successful defense action are different for the various arms participating, measures must be taken to insure unrestricted possibilities for action by the arm with the best prospects of success.

If the air situation is unclear it is better to accept a calculated risk by restricting the action with the less favorable prospects of success in order to avoid hampering the operations of the arm with the better prospects of success.

(3) The best way to secure successfully coordinated action by antiaircraft artillery and fighter forces is to place them both under one tactical headquarters.

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CHAPTER 5

THE AIRCRAFT REPORTING SERVICES

1645 I. ORGANIZATION.

Prior to 1933 the concepts of what was required in the build up of an aircraft reporting service had to be based exclusively on the meager experience available from World War I. Enemy aircraft at the time had to rely on conditions of good visibility for the execution of their reconnaissance and attack missions, and these conditions imposed no restrictions or oral and visual observation from the ground. Such observation was further supported by the use of fiel glasses and sound locators.

The establishment of a network of ground air observation posts, organized in sections each grouped together under a reporting centerto which they turned in their observations, together with the provisions for the processing and evaluation of these reports at the reporting centers to develop the report on the air situation, was thus commensurate with the conditions of the times.

One great advantage in this system was the closely meshed system of wire communication lines existing in Germany, another was that personnel of the various organizations of the

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1645 National Socialist Party after 1933 took over functions in service, in which most posts were honorary, so that no great difficulties were encountered in occupying the observation posts established.

The prewar intention was to develop the observation post network as densely as possible to cover the whole of Germany completely, and to give all observer personnel periodical
1646 training in a system similar to a militia system. The measure giving these personnel Luftwaffe uniforms and reserve military ranks had a very good psychological influence on the personnel, most of whom were no longer young.

It was still an open question how the organization thus developed would work out in actual practice, and the only basis for any prediction here was the experience gained in regionally circumscribed maneuvers.

The most important disadvantages here were that

(1) No possibility existed to test out in practice the efficacy of the aircraft recognition service, since only a few aircraft types were used in maneuvers, some of which in each case were designated as enemy types.

(2) The numbers of "enemy" aircraft and the area in which they were committed were too small to provide a comprehensive picture on the funtionability of the whole system.

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1646 In spite of these drawbacks, the maneuvers did serve to show clearly the large number of reports which would be received at an air observation center. The reaction of the aircraft reporting services to this fact was one of pride at the achievements accomplished, that of the Luftwaffe General Staff was one of concern over the confusion due to the large number of reports involved. It was to be assumed that this confusion would not be any less but even worse in actual warfare, a conclusion which should have been drawn already prior to the war from maneuver experiences.

In the matter of control authority over the aircraft
1647 reporting services it was undoubtedly wise prior to the outbreak of war to place the whole regionally organized system under the various air district command headquarters as the authorities responsible for the direction of air defense activities. When in 1938 the air district commands were given control over the defending fighter forces in addition to the antiaircraft artillery, this produced ideal conditions in the whole air defense organization, with the antiaircraft artillery forces plus the fighter forces and the aircraft reporting services within each air district command area consolidated under one central headquarters. For all participants in the air defense mission this system provided the best conditions possible for smooth cooperation.

1647 Already at an early stage consideration was given to the fact that it would be necessary in the event of war to have a motorized aircraft reporting force for operations in the operational zones of the Army, and enemy territory which might be occupied, to insure the development of a completely closed reporting network. The outcome of these views was the activation of motorized aircraft reporting companies during peacetime in the various air district command areas and organized, commensurate with the special nature of their mission, to transmit their reports exclusively by radio. These units rendered excellent service later, during the war.

It can thus be considered as an established fact that the Luftwaffe aircraft reporting services developed during peace was a system completely in keeping with the times with its regionally organized reporting network and its mobile units, and that it was justifiable to assume that it would give satisfactory results during war in its mission of providing information for the interpretation of current air situations. This
1684 assumption was rendered even more certain in the summer of 1944 when the already developed and tested Freya radar instruments opened up completely new and concrete possibilities for aircraft detection, and were already in serial production for allocation to the aircraft reporting services.

The decisive value of these instruments for the timely

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1684 and reliable interpretation of current air situations was proved impressively when British bombers on 18 December 1939 crossed the North Sea to attack Wilhelmshaven. The resounding success achieved by the defending German fighters and destroyers in Helligoland Bight was possible only because of the early warning given by the Naval Freya radar instruments stationed on the North Sea islands.

All conditions thus existed for a logical development of the aircraft reporting organization towards a system in which the human powers of sight and hearing would gradually give way to observation by electrical instruments, a system which would result in considerable savings in personnel and signal communication facilities because of the greater areas which the individual electrical instruments could cover, which was estimated at approximately ten times that which could be covered by oral and visual observation.

In the first year of warfare three factors contributed to bring about a serious disruption in the organizational set-up of the aircraft reporting services as a part of the air defense organization. These three factors were

(1) The priorities established for the use of electrical target detecting instruments to serve the purposes of the antiaircraft artillery and night fighter forces.

1649 (2) The removal of the fighter arm from command control by the air district commands.

(3) The changed system in which establishments of the night fighter arm and the locally responsible antiaircraft artillery commands assumed the funtions of interpreting the air situation for their own specific purposes, basing their interpretations on their electrical target detecting equipment.

From then on a situation developed which was extremely inappropriate from the organizational point of view, and in which three separate authorities, (1) the aircraft reporting services, (2) the antiaircraft artillery, and (3) the fighter arm each developed their own air situation interpretations on the basis of their own appraisals, so that the different interpretations thus arrived at rarely coincided.

It would have been more to the purpose to have abolished the oral and visual Home Aircraft Reporting Service as an independent organization, while the night fighter arm was being organized, in those areas covered by the radar instruments of the night fighter arm, and to integrate them under control by the night fighter arm.

The same method could have been applied in the local antiaircraft artillery command areas, and the results obtained by oral and visual observation could have been used to check the air situation interpretation based on radar intelligence.

1649 The introduction of electrical instruments for the aircraft reporting services did not mean that it was possible to dispense altogether with natural oral and visual observation. On the one hand it remained necessary to retain human observers against the eventuality of a failure of the technical instruments, and on the other hand oral and visual observation remained necessary to detect and report low-flying aircraft, since it was not possible with instruments operating on ultrashortwave frequencies to detect such targets early enough or to track them long enough.

If the oral and visual observer personnel had been incorporated as above, a system thus would have developed gradually in which first reports on detected enemy aircraft would have come through the electrical equipment and could then have been checked and confirmed by reports from the oral and visual observers established in a perimeter around the night fighter control positions.

However, the Luftwaffe could not make up its mind to interfere with the organization of the Home Aircraft Reporting Service. The inadequacy of the system was recognized, but was to be remedied through increased allocations of radar instruments. Owing to the excessive demands made on the radar manufacturing industry to meet the requirements of the night fighter and antiaircraft artillery arm and the Navy, 1650 the service at no time received anything near adequate allocations of radar instruments. However, the plans to make adequate allocations had the result that the organization of the Home Aircraft Reporting Service continued to exist, or one might say vegetate, as a superfluous adjunct, and continued to absorb unnecessarily large numbers of personnel and instruments and signal communication facilities for its operations.

It was summer 1943 before really serious efforts commenced to improved the performances of the whole service, but even then the objective was to definitely maintain the organization as an independent entity. The plans propounded by the Chief, Luftwaffe Signal Services, at the Special Supplies and Procurement Services conference of 31 August 1943 contained the following provisions:

(1) Increased personnel requirements to develop a more closely meshed network of air observers.

(2) An increased number of report collecting and evaluating centers in the form of sub-air observation headquarters or centers.

(3) Increased equipment with electrical instruments at the expense of the night fighter arm.

1651 At a time already marked by acute shortages in personnel and by the inadequate manufacturing capacities of the radar industry there was no realistic basis on which to found any

1651 hopes that these plans could be effectuated.

It was only under the impact of the absurd incidents of 24 January 1944, when false reports due exclusively to the Home Aircraft Reporting Service showed US 4-engine bombers approaching to attack Nuremberg, Berlin, and Pilsen, that the Commander in Chief of the Luftwaffe found himself compelled to issue the long overdue order to place the Home Aircraft Reporting Service under the fighter commands.

This created the pattern which could have developed organically from the autumn of 1940 on for the zone of interior, and for the occupied western and northern territories: a pattern in which human eyes and ears were integrated with the radar intelligence system.

Other cases in which the methods of employing air intelligence media were organizationally unsound were as follows:

(1) The Radio Intercept Service. Originally, this service had been established at the air fleet headquarters level to serve as an intelligence collecting and evaluating center for the various purposes of air warfare.

The specific interests of the air defense system represented only a part of the overall mission, and it only became possible to give them immediate attention after a liaison detachment from the Radio Intercept Service had been attached permanently to each fighter command head-

1651 headquarters in 1944.

(2) An air reconnaissance service by observer aircraft was only established on the initiative of the fighter command in the summer of 1943 and operated exclusively to serve the specific interests of the fighter command.

In practice it was thus 1944 before centralized authorities at the intermediate level of command, namely, the fighter division headquarters, assumed responsibility for the aircraft reporting services and had available all air intelligence media enabling them to develop interpretations of the air situation as seen from various angles. This achieved the best possible pattern for the organization of the aircraft reporting service. Human faculties served to supplement the information obtained with electrical equipment, and the radio intercept service provided important information on the preparations currently being made by the enemy to serve as an advance warning and create the possibility for accurate predictions concerning the enemy plans, the participating enemy units, possible targets of attack, deceptive maneuvers, and actual intentions. To supplement all this reports from reconnaissance planes provided direct information on what was currently happening. This information thus received from all sources of air intelligence at one central point necessarily resulted in an accurate picture of the air situation, even

1652 even if one or the other component of the system failed or was rendered ineffective by enemy action. How true this was, was characterized by a statement by the Commanding General, 3d Fighter Division, on 5 September 1944 that, owing to the results of enemy action, night air intelligence had to depend exclusively on the reports on sound orientation from the ground air observer posts, on information from the Radio Intercept Service concerning intercepted signals from the enemy Rotterdam instruments, and on reports from friendly night reconnaissance aircraft.

1653 But for the fact that the Home Aircraft Reporting Service had by that time already been assigned under the fighter commands and that a station of the Radio Intercept Service was in operation at 3d Fighter Division Headquarters, it is to be assumed that no possibility at all would have existed to develop an interpretation of the air situation in time to permit timely and appropriately directed operations by the defending forces.

The lessons which can be learned and the conclusions which can be drawn from experience with the German organization of aircraft reporting services are as follows:

(1) The basic requirement for success in air defense operations is an accurate interpretation of the current air situation.

1653 For this reason a properly functioning aircraft reporting service is just as important as the defense weapons themselves.

(2) The services procuring intelligence for aircraft reporting by means of

human observation,

technical instruments,

radio intercept activities, and

air reconnaissance

must be integrated in a firmly consolidated combined arms air defense system and placed under the control of the headquarters directing the combined operations of all participating arms and services.

(3) The compilation and interpretation of the air situation must take place only at that center to which all intelligence reports on the enemy air forces are channeled from all sources.

The air situation report and interpretation thus developed must be binding on all users of such information.

II. PERFORMANCES OF THE GERMAN AIRCRAFT REPORTING SERVICES.

One important problem in aircraft reporting was, from the outset, the proper identification of aircraft by the air observers. In spite of considerable efforts made prior to the war to give air observer personnel training enabling

1654 them to recognize enemy and friendly planes the results remained unsatisfactory. Although aircraft models and silhouettes were used as training aids to impress the characteristic features of the various aircraft types on their minds, personnel were unable to memorize the large variety of enemy and friendly planes involved, and this was particularly so in the case of elderly persons. Commands could do little with innumerable reports concerning "unidentifiable aircraft" and "sounds of aircraft", which served merely to introduce complete confusion into the picture which could have been developed from the usable reports received.

It was a fortunate circumstance for German air defense that the enemy during the early stages of the war were not very active in the air and thus did not impose much of a strain on the German Home Aircraft Reporting Service, and that they only became more active at a time when the night fighter and antiaircraft artillery arms were already developing the radar observation organization.

This transition from the reporting system based on the human faculties of sight and hearing to one based on observation by electrical instruments at the same time called for a degree of specialization so marked that only expert personnel in the operation of radar instruments could produce optimum results.

1655 As the speed and operating altitudes of aircraft increased, and as the air forces as the war wore on became less and less dependent on weather conditions by operating above the clouds and applying blind bombing tactics, the usefulness of visual and oral observation decreased and aircraft reporting became more and more a mission for highly qualified specialists to operate radar and radio instruments, including those of the radio intercept service and those carried by reconnaissance aircraft, namely such instruments as the Flensburg, Naxos Z, and Rossendahl Halbe. Even when the whole system built up on the use of radar instriments was so seriously disrupted, , the reporting system relying on the human faculties at no time achieved a degree of significance which could have justified the enormous expenditure in man power and materiel required for its maintenance.

For these reasons it would have been wise to have arrived at a proper appraisal of the profiency of the human faculties of sight and hearing and on the basis of that appraisal to have based the whole aircraft reporting service at an early stage, primarily on use of the "electrical eye", building human observation into this system merely as a safety factor.

In spite of the remarkable performances achieved in the field, the development of electrical aircraft reporting equipment showed one decisively serious flaw. This was the failure

1655 to provide from the outset against the eventuality of enemy countermeasures to interrupt the functioning of the instruments. Precautionary research work at the proper time probab-
1656 ly would have resulted in an earlier development of those instruments which proved adequately interference proof at the end of the war, such as the Freya Rot and the Jagdschloss.

It was due primarily to this failure to take precautionary measures in time that the German air defense command lacked the most essential requirement for night defense operations from 1942 on, and very frequently for daytime defense from 1944 on, namely, a clear knowledge of the current air situation.

The following lessons can be learned and experience deduced from the performances of the German aircraft reporting services:

(1) In an age when aircraft travel at great speeds and altitudes, and frequently in or above the clouds, no importance can any longer be attached to the employment of the human faculties of sight and hearing to identify them.

(2) A system based on aircraft reporting instruments functioning on the principle of the reflection of electrical waves can only provide a guarantee of reliable operations if they are constructed in line with the results

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1656 obtained through thorough scientific research. The guiding principles in this work of research must be to insure high quality performances and to provide against the eventuality of countermeasures being developed to restrict the effectiveness of the instruments. The final goal must be to construct a highly effective and at the same time interference proof instrument.

(3) Great importance attaches to comprehensive reconnaissance coverage by aircraft carrying electrical search equipment capable of detecting enemy aircraft while these are still over enemy territory. When all other media of air intelligence fail reconnaissance aircraft thus equipped often provide the only possibility to determine the movements of attacking enemy air forces.

(4) Modern means of signal communications, being based largely on the transmission of messages by radio, provide increased opportunities to intercept enemy radio traffic and obtain from the messages thus intercepted a knowledge of enemy preparations for operations and of the course on which enemy forces are approaching.

For the above reason the importance of a well organized radio intercept service is at least equal to that of the other media of air intelligence.

(5) The great extent to which a modern aircraft

1657 reporting system will be based on technological elements necessitates thorough training of highly qualified specialist personnel to operate the equipment used. Accordingly the only personnel who can be used in the service are professional military personnel enrolled for a long period of time, or technological personnel employed under long term civilian contracts.

CHAPTER 6

GERMAN PASSIVE AIR DEFENSE

I. ORGANIZATION.

The first measure of decisive importance so far as the whole development of the passive air defense system was concerned was the decree issued on 1 April 1934 placing all passive air defense matters under the Reich Minister for Aviation. This arrangement remained unchanged up to the end of the war.

The system included the highly diversified missions of gas defense, fire precautions and fire fighting, camouflage, the construction of dummy installations, smoke screening, the construction of air raid shelters, the air raid warning service factory air defense, individual protection, safety and auxiliary services, and when one considers the vast scope of this complex field of activities the question presents itself to the mind whether the measure taken in 1934 was sound in principle.

For the following reasons the answer to this question must be in the negative:

(1) The various missions of passive air defense affect the Nation and the State in their entirety, and therefore can only be handled appropriately by a State authority at the very highest level.

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1658 (2) The Reich Minister for Aviation was at the same time Commander in Chief of the Luftwaffe, so that the execution of the missions of passive air defense were relegated to the various commands of the Luftwaffe. The outcome of this situation was that problems developed involving the question of proper authority and the power to interfere in the affairs of areas of interest outside the scope of the Luftwaffe. These circumstances had an exceedingly hampering influence on the procurement of personnel and materials.

(3) For the Luftwaffe the responsibility for all passive air defense matters implied a mission of such vast dimensions that it proved too serious a load on the whole command organization. As a result, the Luftwaffe while executing its tactical and operational mission of aggressive and defensive air warfare devoted too little time and interest to the problems of passive air defense to place them on a plane commensurate with their high importance.

This becomes quite obvious from the fact that it was 1941 before measures were taken to establish a separate Passive Air Defense Inspectorate (L In 13) within the Reich Air Ministry. Further evidence is the fact that, although a "Fuehrer" Passive Air Defense Program

1659 providing for the construction of air raid shelters was established in 1940 and revised in July 1941, measures to put the program into effect only started in January 1942.

It would have been much wiser to establish from the outset, or at the beginning of the war at the latest, a national office at the very highest level and not part of the military establishment responsible for the missions of passive air defense. Such an office would have had the necessary authority to interfere when necessary in the matters of individuals and in those of the Nation and the State as a whole.

In spite of what has just been said, the important personality of the Commander in Chief of the Luftwaffe did enable the Luftwaffe to show remarkable organizational performances prior to the war in the development of passive air defenses. Under the powers of authority received through the Passive Air Defense Law (Luftschutzgesetz) of 26 June 1935, all branches of passive air defense were well organized by the outbreak of war, and the necessary personnel were properly trained and firmly organized. In this field again it was a great advantage that the influence of organizations of the National Socialist Party insured public cooperation.

However, one field of activities was badly neglected, namely the construction of air raid shelters capable of providing real protection even against the heaviest types of

1660 bombs of calibers used by the Luftwaffe itself.

The generally ruling concept was that the cellars of their houses would be the places to provide shelter for the civilian population in the event of air attacks. A serious examination of the problem would have shown this theory to be fallacious.

That this problem was not taken very seriously prior to the war was undoubtedly due to the feeling of security stemming from the existence of the Luftwaffe and to a general underestimate of enemy capabilities.

This flaw in the organization of passive air defense--this failure to construct proper air raid shelters--produced direly serious consequences. At a time when the inadequacy of the protection afforded by cellars had already resulted in heavy losses among the civilian population during air attacks, the general military situation was such that it was impossible to make adequate man power or materials available to remedy what had been neglected in the past.

The measures taken in 1943 to reorganize the direction of passive air defense activities within the Luftwaffe through

1661 the establishment of a separate Passive Air Defense Branch in the Luftwaffe General Staff and of the Passive Air Defense Planning Staff (_Arbeitsstab Luftschutz_) in the Passive Air Defense Inspectorate could not bring about any changes in the

1661 situation of general shortages and served only to produce new unattainable programs.

Even the measures of February 1945 to reorganize the whole system through the establishment of an Office of the Chief of Passive Air Defense directly under the Chief of the Luftwaffe General Staff remained nothing but a post festum measure.

The whole weakness was not due to any lack of capable men or ideas within the ~~tm~~ passive air defense command organization, but to the shortage of man power and materials in general and, in the final essence, to the fact that the Luftwaffe did not have the necessary authority to force the issue against the will of the Wehrmacht High Command and the ministerial departments of the Government in this matter which affected the whole Nation. After 1943 Reich Marshal Goering no longer had the influence and the powerful position within the Government which prior to the war had served to bring about the elaborate development of the passive air defense system. Consequently it was not possible to bring about the expansion in personnel and materiel which would have been necessary to alleviate the effects of the growingly severe air attacks and to speedily repair the damages done.

The following lessons can be learned and experience drawn from the German organization for passive air defense:

(1) A passive air defense organization must have

1661 powers of authority superceding all organizations of the State and the Nation.

(2) A single, firmly directed uniform organization must be responsible for all missions of passive air defense.

(3) The passive air defense organization must be so far developed during peace that it can commence functioning immediately in the event of a surprise war and will have adequate man power and equipment available.

(4) In industrial regions and large cities air raid shelters must be prepared during peace to provide protection for the civilian population.

II. PASSIVE AIR DEFENSE FORCES AND MEASURES OF PASSIVE AIR DEFENSE.

1. The Air Raid Warning System. The establishment of an efficient air raid warning system hinged upon the following factors:

a. A clear interpretation of the current air situation.

b. Secure signal communications for the transmission of air situation reports to the appropriate air raid warning centers.

c. Timely and proper decisions concerning the type and scope of the air raid warning to be given.

1662 d. The existence of technical facilities to warn the civilian population.

These basic requirements tied the air raid warning system closely to the aircraft reporting services on the one hand and to the local antiaircraft artillery commands on the other. The former gave information on the extent of the current hazards, the latter information on the time and scope of the warning to be given. Inadequate clarity in the air situation could result either in (a) the sounding of too acute an air raid alert, or (b) the sounding of a too low stage of air raid alert at too late a time. These two questions alone embodied a large share of the whole complex of problems involved in the air raid warning system.

The fundamental concept ruling in Germany was that ~~the~~ civilian population under no circumstances was to be exposed without warning to sudden air attack. Therefore, the practice was established of rather sounding an alert which might be too acute than otherwise. Even at a time when this practice quite obviously had an excessively serious hampering effect on the armament output and became the subject of heated contention between the commands and the authorities responsible for armament production, the Commander in Chief of the Wehrmacht personally decided that the principle was to be

1663 retained. This strictly observed rule remained in force unchanged until 27 August 1944. The new regulations established on that date weakened the principle to some extent by providing that when individual enemy aircraft penetrated, meaning a force not exceeding twelve aircraft, a public alert was to be sounded but that each individual could then decide for himself what form of air raid precautions to take.

In many cases too frequent air alerts did more psychological harm to the individual than could have been done if he he had come face to face suddenly with the acute hazards of an air attack. Furthermore, too great frequency contained an element of risk that the air raid warnings would not be taken seriously enough and that the population might fail to respond properly and thus be taken unawares in their homes or at their work by heavy bombing attacks.

A good solution to these problems was found in the air situation reports broadcast by the fighter divisions under the call signal "Primadonna meldet....." These broadcasts were transmitted on a permanent frequency which any receiver could pick up, and gave the public direct information on the current air situation from a proper authority. However, this system could not serve to fully replace the use of public warnings, since it had to remain possible to reach the public by other means at all times and in all places to warn them

1664 against an imminent air attack. Nevertheless, the air situation reports transmitted by the fighter divisions in clear text did serve to give the public a definite idea of the extent of the imminent hazards and resulted in timely and calculated precautionary behavior. The disadvantage that the enemy also could intercept these messages and determine from them the extent to which their deceptive measures had succeeded, had to be accepted as a necessary drawback in a measure designed to safeguard the population.

With the mounting speed of aircraft the air alert warning radius--meaning the perimeter line from which the advance warning had to be sounded as soon as it was crossed by enemy aircraft--also expanded. The tactics of the Royal Air Force of sending small forces of Mosquito bombers almost daily into Germany in various directions necessarily resulted in large areas being alerted. These almost regular nightly alerts in most of the major cities imposed a severe psychological strain on the population and caused widespread cessation of work, although only a few points then came under attack with bombs.

Right up to the end of the war no satisfactory solution to this problem of too frequent and unnecessary alerts in the case of penetrations by "fast enemy bombers" was found.

1665 It is probable that no real solution can be devised which in such conditions would serve to protect the population and at the same time avoid unnecessary distrubances.

2. Fire Precautions and Fire Fighting. It is a matter of experience that in World War II the damage done by air attack was due in a far greater measure to the use of incendiary bombs than to the use of explosives. In what might be called a chain reaction these incendiary bombs set whole residential areas on fire, and in any type of industrial installations they served to spark a holocaust of fire.

Prior to the war the fire fighting service was well organized in Germany. In large cities regular fire fighting services were maintained; in smaller towns and villages it was considered a matter of honor to be a member of the local voluntary fire brigade.

Great efforts were also expended to promote individual fire precautions by the population. Each house had its air raid warden who was required to insure that easily flammable material was removed from the attic and that boxes of sand and buckets of water were available and in place to extinguish inexndiary bombs.

In each industrial installation the factory air defense
1666 organization provided for immedaite action to extinguish fires the moment they started. In their motorized security

1666 and auxiliary service units the air district commands had available a ready reserve which could be dispatched speedily to support the local forces in areas seriously stricken.

All of these measures were well considered and proved excellent when put to the crucial test. With the increasing severity of air warfare from 1943 on it became merely a matter of whether adequate personnel and equipment were locally available to take timely fire fighting action with sufficient forces in all places at once.

However, the effects of hundreds of thousands of incendiary bombs dropped in a single attack on a large city proved so catastrophic that even a plurality of the forces actually available would have been inadequate.

The whole situation is characterized by the following quotation from the Inspector of Fire Fighting Services, General Rumpf: ".....after an air attack the fire fighting units in a city can decide which two out of each hundred fires reported they will endeavor to extenguish, leaving the other 98 to take care of themselves."

It must therefore be considered here as an established fact that the missions which developed during the war for the fire fighting services exceeded by far the forces and materiel which could be made available for the purpose.

1667 3. Camouflage and Concealment. During peactime already the German military forces attached great importance to the subjects of camouflage and concealment. This fact found expression in the fact that in the choice of terrain, in the form of construction, and in the way military installations were painted, due regard was given to the principle of making everything inconspicuous from the air.

However, all of these efforts failed to produce results which could have justified the expenditures involved. It proved just as impossible to conceal these installations from foreign espionage as it was to conceal similar installations in foreign countries against German discovery. It must be accepted as an established fact that it is impossible during peacetime and under conditions of unhampered international travel to keep vitally important military installations and industries of military importance concealed against foreign observation.

The situation is entirely different during war, when strict controls can be maintained against infiltration by hostile secret agents after the borders have been closed. Even then, however, the possibility of extensive enemy espionage activities must be taken into account, since no absolutely secure form of protection exists against the modern system of

1667 of dropping agents from airplanes by parachute.

On the whole, the highly diversified measures employed on the German side to conceal important installations of the armament industry after the outbreak of war were valueless. The enemy had already recorded the location of all factories during peace, and systematic air reconnaissance enabled them to keep track of all changes. What the human eye was unable to detect from altitudes of between 23 000 and 33 000 feet, the experienced air photo interpreter could find without fail.

During the time of visual bomb aiming the precision of a bombing attack still depended on the accurate entry of the target on the map and the presentation of the target in its most recent configurations in air photos, and on the ability of the bomber to identify from the air the target thus presented. With the improvement of navigational aids and the replacement of the human eye by television in the form of such instruments as the air-carried Rotterdam and Meddo, even the very best camouflage proved ineffective.

Only two forms of concealment remained absolutely effective during the war:

(1) The establishment of new factories, not known to the enemy from before the war, in a loosely organized system deep inside large forest areas, or underground.

1668 Typical examples here were the Messerschmitt factory installations in the Burgauer Forst forest and in the wooded areas near Regensburg.

(2) The reestablishment of factories under the ruins of their former premises. However, this form only proved effective as long as the enemy intelligence failed to discover the fact that work was continuing at the old location.

For practical purposes, all other measures of camouflage and concealment taken in Germany were useless, since it was not possible to conceal or disguise all terrain feature which could serve as a guide to the installations as effectively as the installations themselves could be concealed or disguised. When or whether the installations would come under attack was merely a matter of how such an attack fitted into
1669 the strategic concepts of the enemy.

Using the Boomerang or Diskus method the attacking aircraft did not even require to see their target in order to hit it with an accuracy of plus-minus 660 feet or, acting as pathfinders, to mark the target for mass bombing.

Even the construction of dummy installations could only achieve some measure of success by drawing the attacking bombers away from the real target while the navigational and aiming devices available to the enemy were not yet precise enough

1669 to attack the target without visual aiming. When the enemy introduced their Pathfinder system, dummy installations no longer had any significance at all.

What has been said above applies equally to blackout measures. The German population observed the blackout requirements very conscientiously, but as the war drew on such measures no longer served their original purpose of making orientation difficult for the enemy.

4. Smoke Screening. Smoke screening as a means to temporarily conceal particularly important installations against air observation could only be considered as an effective means of passive air defense as long as the enemy had to depend on visual aiming in their bombing attacks.

On the German side the employment of smoke units became a matter of acute current importance when the US Air Forces commenced their campaign of strategic daytime attacks. In contrast with the British area bombing tactics, the American attacks were directed consistently against all types of important military installations as point targets.

At this juncture the Luftwaffe had available only nine smoke companies. Three of these were deployed in France and six within Germany, primarily for the protection of hydration works and naval bases. The increased severity of air warfare in 1943 resulted in an accelerated build up of the smoke arm, 1670 a measure which for a while proved exceptionally profitable. Smoke screening in the Ploesti oil region of Rumania, for example, created serious problems for the enemy and provided more effective protection than fighter and antiaircraft artillery forces could have given.

However, once the Americans had developed their Pathfinder system far enough, using Meddo instruments for the purpose, smoke screening of targets no longer served any useful purposes. The German smoke projector arm grew to a considerable size during the war by the time the perfection of blind bombing methods had developed to a stage which made the use of smoke as a means of concealment illusory.

5. <u>The Transfer of Factories to New Locations</u>. One result of the daytime precision bombing attacks by US air forces and of the more clearly defined concentration of night attacks by Royal Air Force units against large industries was that the German side from 1943 on commenced a systematic transfer of industrial factories from the exposed areas to locations where they would be safer. Some were reestablished in natural or man made caves or tunnels underground or in disused mine shafts, others moved to newly constructed sites, also underground, or to a number of smaller factories newly established for the purposes at some distance from large cities and traffic

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1671 centers.

Passive air defense measures of this type were extremely effective. Above all, it was measures of this type which made it possible to continue air armament production and, in spite of the increased intense severity of enemy air attack, to achieve an immense output in aircraft under the 1944 fighter aircraft production program.

However, the transfer of factories could only be carried out at the cost of enormous expenditures and in the end could not prevent destruction of the aircraft produced on the airfields where their final assembly took place. It was here tha the parts manufactured in the subsidiary factories wereput together and the finished planes had to make their test flights. The only exception here was in the case of those aircraft which, as was the case with those assembled in the Messerschmitt factory in the Burgau Foret forest, could take off unnoticed from the nearby autobahn for the delivery flight to the specified points of delivery.

In other branches of industry, for example in the case of factories manufacturing ball bearings, the transfer of manufacturing installations to new sites had the result that no shortages in such articles occurred throughout the war, so that all needs of the armament producing industries could be met.

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1672 There can be no doubt that even much better results could have been obtained if measures of this type had been introduced before 1943. A sober appraisal of the situation created by the entry of America into the war, which gave the enemy vastly increased potentials in the armament production field, and particularly in the field of armament for air warfare, should have resulted in earlier measures of this type, and a serious start definitely should have been made immediately the fact became known to the German Command that US 4-engine air forces had displaced to England in April 1942.

As was the case in so many fields, a serious lack of precautionary initiative is noticeable here on the German side. In the matter of the transfer of important industrial installations German measures, as in so many other cases, were only taken when made necessary by the action of the enemy bombers.

6. Air Raid Shelters. Up to the time when the attacks by Royal Air Force units in 1943 became increasingly severe because of the larger size of the attacking units, the use of larger caliber demolition bombs and larger numbers of incendiary bombs, the opinion was held in Germany that the cellars of their houses would provide adequate protection for the civilian population against the effects of air attacks.

The increasing severity of the air attacks resulted in a

1672 rapid rise in the number of casualties caused in the air raid cellars by the blast effect of heavy demolition bombs which penetrated right through entire houses into the cellars. Even graver were the large number of people killed by the resultant fires, which caused the suffocation of people seeking shelter in their cellars.

This made the construction of bomb-proof air raid shelters for the population of densely settled residential areas a problem of the first magnitude and urgent importance. Owing to the inadequacy of the building materials and facilities available it was impossible up to the end of the war to carry out such constructions in the necessary scope.

It was found that there were only two possibilities to provide really effective protection against the effects of air attacks:

(1) The use of natural or man-made sites, such as caves or tunnels, with a bomb-proof covering.

(2) Concrete bunkers.

Where caves or tunnels or similar shelters were within reach of the civilian population, these were outfitted to serve as mass air raid shelters.

The construction of concrete air raid shelter bunkers was given high priority, but owing to the inadequacy of the building materials, man power, and facilities available it

1673 was not possible to carry out the programs established except to a very limited degree.

Here again, the late start made in taking the necessary precautions resulted in the loss of numerous lives which could have been avoided by timely planning.

1674 II. PASSIVE AIR DEFENSE FORCES AND MEASURES OF PASSIVE AIR DEFENSE.

EXPERIENCE AND LESSONS

The following lessons can be learned and experience drawn from the employment of the German passive air defense forces and from the measures of passive air defense which were implemented:

1. In an era of constantly increasing aircraft speeds and steadily increasing effectiveness of the means available for air attack, which are such that even a single ~~plan~~ plane can constitute a deadly hazard for innumerable people in densely settled residential areas, measures to give the population timely warning of an impending air attack become a matter of life or death for thousands of people. In order to sustain the will of the population to resist, the first principle of an air raid warning system definitely must be to insure that nobody shall be taken unawares by an air attack without having been warned.

2. Direct communication contacts must exist between

1674 the centers responsible for the compilation of current air situation reports on the one hand and the authorities responsible for orders to sound the air raid warning on other hand.

3. In modern air warfare personnel requirements are exceptionally large for action to extinguish fires resulting from air attacks. A decisively important point here is that the possibility must exist for action to extinguish large numbers of fires simultaneously while they are still small.

Besides the establishment of local fire-fighting units and measures to give the public training enabling them to protect themselves against fire, strong mobile reserves are required to reinforce whenever necessary the local forces in attacked areas.

4. The extensive repairs which become necessary after any air attack to restore the interrupted water, gas, and electricity supply systems necessitate the maintenance of locally organized strong technical units in addition to a mobile reserve of such forces to reinforce those in emergency areas.

5. In the event of war measures must start immediately to move all installations which are of vital importance for the conduct of war to bomb-proos premises. It must

1675 be assumed with certainty that the location of all existing factories of military importance are known to the enemy and will be taken under attack.

All new factories or other installations must be established from the outset in bomb-proof premises.

6. All measures of camouflage, concealment, and deception, such as smoke screening, blackouts, and the construction of dummy installations will have practically no significance because of the technological developments which have made attacking forces independent of visual observation.

7. The only possible way to provide effective protection for the civilian population is through the construction of bomb-proof shelters. The enormous expenditures this involves makes it necessary to to carry out the construction program in time before the outbreak of a war.